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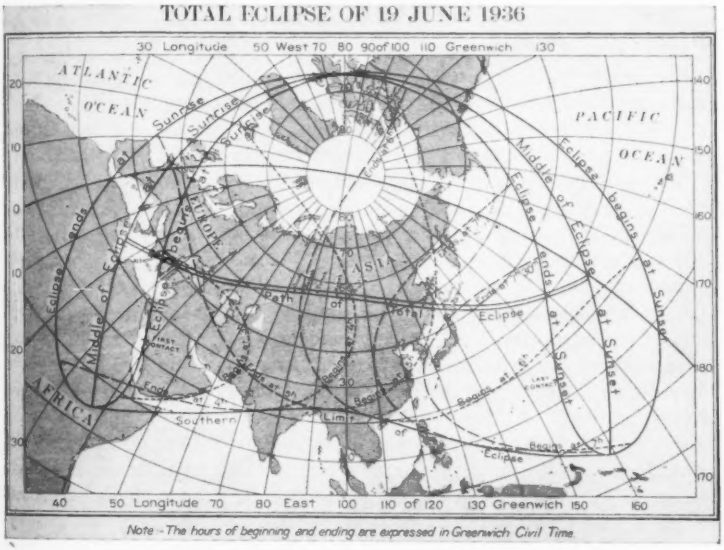
The Total Eclipse of the Sun on June 19, 1936

This is the only total solar eclipse for the year and many eclipse expeditions are being undertaken for the purpose of observing it. A number of details relative to this eclipse are to be found on pages 28 and 30 of the January, 1936, issue of this magazine. It is there shown that the path of totality extends generally across the continents of Europe and Asia. For convenience of reference the chart published in the January issue is repeated here.


TOTAL ECLIPSE OF 19 JUNE 1936
30 Longitude 50 West 70 80 90of100 110 Greenwich 130
ATLANTIC OCEAN
PACIFIC OCEAN
ASIA
AFRICA
Sunrise
Sunset
Middle of Eclipse
Eclipse begins at Sunset
Eclipse ends at Sunset
Eclipse ends at Sunrise
Middle of Eclipse at Sunrise
Eclipse begins at Sunrise
Path of Total Eclipse
Southern Limit of Eclipse
40 50 Longitude 70 80 East 100 110 of 120 130 Greenwich 150 160

Note - The hours of beginning and ending are expressed in Greenwich Civil Time.

Various astronomical societies in Russia have made exhaustive studies of conditions along the path of totality and have published the results for use of those making plans for observing this eclipse. For example, Mr. A. Michailov, under the auspices of The Sternberg State Astronomical Institute, has published a large-sized pamphlet of thirty-six pages, supplemented with three large-scale maps and numerous tables of meteorological and astronomical data. To make the information it contains the more readily accessible the pamphlet is printed in Russian and

in English, in parallel columns. It is entitled "The Eclipse of the Sun June 19, 1936, in U.S.S.R."

We quote the following general statement from this pamphlet:

"The path of the Moon's shadow begins in the Mediterranean Sea near Tripoli, crosses Southern Greece and Asia Minor, where the eclipse is seen in the early morning and totality is of short duration. After crossing the Black Sea, the shadow enters near Tuapse the Caucasus and traverses the whole continent of Asia —a distance of some 7200 km in $2^h 13^m$, moving with an average speed of 900 meters per second. The path of the shadow goes then over the northern part of the Sea of Japan and touching the island Hokkaido it loses itself in the Pacific Ocean.

"The path of totality reaches its greatest breadth equalling 132 km and the total eclipse its longest duration of $2^m 31^s$ in mid-Siberia just west of the Baikal lake, where the Sun's height during totality is also the greatest (57°)."

Indicative of the minute details of this survey we quote again.

"The mountains on the Moon affect several phenomena, and in some cases it is desirable to know the irregularities of Moon's limb produced by them, either at the point of contact, or on part of the limb. These irregularities are shown on the diagram below, prepared from Hayn's chart of Moon's topography."

Accompanying this statement is a full-page chart showing the contour of the surface of the moon through 360° of position angle.

In addition to this large pamphlet, two smaller ones have been issued as Bulletins of the Commission for Researches on the Sun, XIII and XIV, the former, under the authorship of B. P. Gerasimovič and Ščerbakova, the latter, under the authorship of A. Michailov. The former divides the entire path of totality within the borders of U.S.S.R. into four sections and discusses each one as to weather, clouds, accessibility, topography, population. A table of railroad fares and several charts are added. The latter is not concerned with general considerations but relates to technical aspects of special features.

An additional large-scale map, five and a half feet in length, displays the path of totality with the locations already chosen by eclipse parties clearly indicated. Preparations are under way on the part of seventeen Soviet Astronomical Expeditions and eight Soviet Geophysical Expeditions. Also ten foreign eclipse expeditions will be located in the U.S.S.R. territory. They are: Société Astronomique de France, at Beloretchenskaya; Kyoto University (Japan), near Armavir; Harvard College Observatory, at Ak-Bulak; Italian Academy of Sciences, at Sara; Paris Observatory, at Sara; National Geographical Society, U.S.A., and Georgetown University Observatory, at Kustanay; Expedition of Polish Astronomers (Cracow, Warsaw), at Javlenka; Astronomical Society of Czechoslovakia, at Javlenka; British Royal Society and Royal Astronomical Society, at Omsk; Kyoto University (Japan), at Omsk.

The National Research Council of Japan has issued a small pamphlet of sixteen pages entitled, "Information for the Total Eclipse of the Sun on June 19, 1936." Accompanying the pamphlet there is a detailed map

of the northern edge of the island Hokkaido, the large northern island of Japan, which is touched by the shadow. After general information concerning conditions on the island the pamphlet devotes a section to the subject of suitable observation sites. We quote the introductory paragraphs as follows:

"The Eclipse Committee, last summer, had some of its members proceed to Hokkaido and look over a number of places along the central line, but obviously they could not visit all the possible suitable locations, seeing that the zone is nearly 400 km long. There are so many suitable sites for making observations that it is difficult to make a choice. We shall therefore confine our descriptions to a few places that are well known.

"Needless to say, the first consideration in selecting a station is the chance of a clear sky, and with this important requisite in mind, we have selected the regions of Naka-Tombetsu, Mombetsu, and Shari, all easily accessible by railway. Accommodation is also available in villages other than these three, such for example as Esashi, Omu, Okoppe, Shimo-Yubetsu, Abashiri, Koshimizu, etc. All these towns and most of the villages are supplied with electricity (about 100 volts, alternating current). Conveyances in the form of automobiles and motor-trucks, as well as material necessary for erecting the station, such as timber, cement, etc., are readily obtainable, as also coolies and carpenters. The daily wages of these laborers range from 1.30 to 2.00 yen.

"The primary schools of most towns and villages have spacious playgrounds of 5,000-10,000 square meters, which the schoolmasters will gladly place at the disposal of the observers. These grounds, being more or less isolated and capable of being closed off from the idle and curious, form ideal stations for observers."

Then follow detailed statements concerning a dozen or more sites which might be selected. The pamphlet concludes with the following friendly paragraph:

"Lastly it should be mentioned that the authorities of the Hokkaido Prefecture are ready to extend every possible assistance to visiting observers in order to render their stay both pleasant and successful. Astronomers in whatsoever country, who may be planning an eclipse expedition, are requested to communicate with the secretary of the Eclipse Committee, National Research Council, Ueno Park, Tokyo, when further necessary details and any other desired information will be gladly supplied."

The Harvard College Observatory Expedition

The Harvard Observatory and Massachusetts Institute of Technology are coöperating in sending an expedition to Siberia. We plan to join the Poulkovo expedition headed by Dr. Gerasimovič. The stations will be located near Ak-Bulak. Some last-minute changes may be made in the observing program, but our present plans include observation with eight spectrographs.

Two spectrographs with 21-foot concave gratings, with 20,000 and 30,000 lines per inch respectively will be used in conjunction with a moving-film camera to record the entire solar spectrum from 3900 to about 6800A. With this instrument we also plan to make a study of the solar disc at various wave-lengths in the solar spectrum, both limb dark-

ening and intensity distribution. These concave gratings will be used in parallel light and will be fed from a coelostat mirror.

Four plane gratings, fitted with cameras and lenses of focal length from 5 to 8 feet will be used to cover the spectral regions from about 3200A to 10,000A. In these spectrographs we plan to use the "jumping" film or "jumping" plate as a method of recording of the spectrum of the arcs. The four spectrographs will be mounted in pairs on the upper and lower surfaces of the spectrograph box, a sort of double-decker arrangement . These spectrographs are mounted on a polar axis and fork and driven by clock work. An additional spectrograph, employing ultra-violet prisms and a moving-film will be mounted on top of the box and turned with the same polar axis. These seven spectrographs together with the polar axis mount and fork are the gift of the Dow Chemical Company, of Midland, Michigan. They are made of *Dowmetal,* a very light magnesium alloy, whose lightness and strength make it admirably suited to the requirements of eclipse equipment. The eighth spectrograph is a Bausch and Lomb slit spectrograph, with quartz lens and a quartz half-prism aluminized on the back to form a Cornu Littrow-type instrument. The image lens is of fluorite crystal. These spectrographs will be used to record the spectrum of the corona and of the chromosphere.

In addition we hope to have one 60-inch camera for coronal photography and we hope to make some studies of coronal polarization.

In addition to the purely astronomical side of the program, we are taking several powerful radio transmitters and receivers for the purpose of making studies of the effect of the eclipse upon the ionosphere. Two of the instruments are of fixed frequency type and the other a variable frequency type by means of which the lag in the return of pulses from the Heaviside layer can be determined. The official party includes:

Dr. and Mrs. Donald H. Menzel, of Harvard Observatory.

Dr. and Mrs. Joseph C. Boyce, of M. I. T.

Mr. Henry Hemmendinger, of Harvard Observatory.

Miss Henrietta Swope, of Harvard Observatory.

Dr. and Mrs. A. H. Benfield, formerly of Harvard Observatory and now of Oxford, England.

Dr. R. d'E. Atkinson, of Rutgers University.

Dr. and Mrs. Wallace R. Brode, of Ohio State University, and Miss Catherine Stillman, of Vassar College. Dr. Brode is making a special study of band spectra in the flash by means of a moving-film spectrograph.

Dr. and Mrs. I. C. Gardner, of the Bureau of Standards and Miss M. O'L. Crowe, of the State Department of Health at Albany, N. Y., will probably be located at the same point.

The members of the party who are devoting themselves mainly to the radio experimentation are:

Mr. Paul King, of Harvard University.

Mr. H. Selvidge, of Harvard University.
Mr. G. W. Pierce, of Harvard University.
Mr. E. P. York, of Harvard University.
Mr. Jackson Cook, of M. I. T. DONALD H. MENZEL, *Director.*

GEORGETOWN UNIVERSITY-NATIONAL GEOGRAPHIC SOCIETY
TOTAL SOLAR ECLIPSE EXPEDITION, JUNE 19, 1936

The Georgetown-National Geographic Society Expedition will go to the town of Kustanay—the terminal of the Tcheliabinsk-Kustanay railroad—about five hundred miles east of Orenburg. The town (53° 12′ N, 63° 38′ E) is about 5 km north of the central line. Time of the mid-totality $4^h\ 25^m.6$ G.C.T.—$8^h\ 40^m$ A.M. Local Time. Duration of totality will be 127 seconds; the elevation of the sun 42°. The meteorological data based upon observations extending over a period of several years, published by the Central Geophysical Observatory in Leningrad, show a high probability of clear weather for the region about Kustanay during totality, about 70%.

Personnel of the expedition.

Paul A. McNally, S.J., Ph.D.—(Director, Georgetown College Observatory), Director.
Emeran J. Kolkmeyer, S.J., M.A.—(Chairman, Physics Department, Georgetown University), Assistant.
Thomas J. Smith, S.J., M.A.—(Assistant, Georgetown College Observatory), Assistant.
William Robert Moore—(National Geographic Society), Photographer.
Carl H. Spriegel—(Georgetown University), Instrument-maker.

Program.

65-foot, tower telescope—Direct photographs of inner corona and expanse of corona.
Ross lenses, 63 inches and 21 inches focal lengths.
Direct photographs—panatomic emulsion.
Direct photographs—with series of filters for photometric determination of radiation in several regions of the spectrum.
Several exposures will be made with the 21-inch using an objective grating, 2000 lines to the inch.
Spectroscopic.
Concave grating—using the new Eastman emulsions R, P, M, Q, Z—sensitive in the far infra-red. This grating will also be used for the flash spectrum.
Quartz spectrograph—ultra-violet radiation. This spectrograph will be used with a moving plate.
Plane grating—slit and moving plate. Continuous exposures before and after second and third contacts.
A combination of photo-electric cells and electroscope—self-recording—for the measurement of the variation of light intensity from first contact to fourth contact.
A series of direct photographs of the crescents, before and after totality, will be taken for the purpose of checking on the direct observations of the contacts.

PAUL A. MCNALLY, S.J., *Director.*

DR. JOSEF J. JOHNSON, of the California Institute of Technology, plans to observe the coming eclipse from Hokkaido, Japan, continuing his program of measuring the polarization of the corona which was inaugurated at the eclipse of February 14, 1934.

Greek Astronomers During the Fourth Century B. C.

By A. WILLARD TURNER

Introduction

In the following pages we have attempted to describe the astronomical views of Plato and Aristotle, and, more especially, the contributions of those individual Greek astronomers who are associated with the fourth century B.C. Such description is tantamount to a fairly general outline of the astronomical progress of the century—for early astronomical history appears to be limited to a fragmentary knowledge of individual achievement.

In the days of ancient Greece, various branches of knowledge were incorporated in the all-inclusive study of philosophy. Since astronomy was no exception, a study of its early growth can scarcely be differentiated from the astrology, mysticism, and metaphysics of Greek philosophy, even though we can detect sound scientific methods of reasoning in many of the seemingly fantastic cosmological systems of Greek philosophers. By the fourth century B.C., the autonomy of scientific astronomy was beginning to assert itself. For example, we find Eudoxus—the greatest astronomer of the period—liberating his theory of planetary motions from the philosophical reasoning which had colored similar discussions prior to this time.

The fourth century has a peculiar significance, in that it was dominated by those two great master spirits of the ancient world—Plato and Aristotle. Their names far transcend all others in the history of Greek philosophy and learning, for their personalities and philosophical systems have influenced and moulded thought throughout all ages.

Plato flourished during the first half of the century, and the astronomers Eudoxus, Ecphantus, and Philip of Opus are usually connected with this time. With Aristotle—who marked the second half of the century—we find the astronomers Callippus, Heraclides, and Autolycus.

I. Plato (πλάτων) : c. 427 B.C. - c. 347 B.C.

Plato—who was originally named Aristocles—was the son of a wealthy and ancient aristocratic family in Athens. Early in life he became a devoted disciple of Socrates, who was so fearlessly opposed to the pernicious elements of sophistical culture that he was most unjustly condemned to death.[1] Plato's entire philosophy and life were profoundly and decisively influenced by his association with Socrates, whose true successor he became.

[1] Trial scene described in Plato's Phaedo.

Around 388 B.C., Plato founded the earliest school of philosophy, called the Academy. This school was the most famous university of antiquity, and lasted for more than nine centuries. While the dialogues wherein Plato expounded his idealistic philosophy have come down to us in a much more complete and finished form than the writings of most Greek thinkers, many of his scientific views are shrouded in poetic fancy, mysticism, and romance.

Unfortunately, his tremendous prestige as a philosopher has led some of his ardent admirers to attach undue importance to his astronomical ideas. Actually, it is quite probable that his cosmic views on astronomy were much less advanced than those of contemporary Pythagoreans, who had made the earth a planet like the other heavenly bodies revolving around the central fire. Plato's ideas are discussed chiefly in the Timaeus, where he definitely supports the doctrine that the earth is stationary with the heavens rotating around it daily.

Although astronomy occupied the fourth place in the curriculum of the Academy, Plato's attitude towards this science was exceedingly strange. While he had a very high respect for mathematics, he considered experiment and observation extraneous to true science. Astronomy for him was "a kind of ideal kinematics, a study in which the visible movements of the heavenly bodies are only useful as illustrations."[2]

It is quite clear that Plato's astronomical system was nothing more than the simplest geocentric one, and that he does not occupy a prominent place in the progress of astronomy proper. Nevertheless, his emphasis upon systematic analysis and mathematical methodology are of importance in the history of any science.

II. Eudoxus (Εὔδοξος): c. 408 B.C. - c. 350 B.C.

Eudoxus[3] of Cnidus, one of Plato's pupils, was the most outstanding astronomer and mathematician of the century. His contributions to geometry are sufficiently important to deserve mention here, especially since the intrinsic essence of his astronomical system was geometric. Primarily, Eudoxus invented the theory of proportions which formed the basic content of Book V of Euclid's Elements. Secondly, he is credited with the discovery of the method of exhaustion, by which he proved various theorems concerning the areas of circles and volumes of cones and pyramids. Incidentally, Heath ranks Eudoxus as one of the two leading mathematicians of antiquity, the other being Archimedes.

Eudoxus' fame as an astronomer rests chiefly upon the remarkable system which he developed to account for the motions of the sun, moon, and five known planets (Mercury, Venus, Mars, Jupiter, Saturn). The problem is said to have originated in a challenge of Plato, who propounded it to his pupils for solution. Although the book "On Speeds,"

[2] Heath: Aristarchus of Samos, p. 138.
[3] Turner, A. W.: Five Great Greek Astronomers. *Jour. Royal Astron. Soc. Canada*, Vol. XXIX, Nos. 4 and 5.

in which Eudoxus explained his system, was lost, evidence concerning the details was given by Aristotle and by Simplicius, while a modern comprehensive outline is contained in Dreyer's "Planetary Systems." Since the theory under discussion (frequently called the homocentric theory) is quite complicated, we shall attempt to give but a very superficial account of its leading features.

Eudoxus envisaged a combination of twenty-seven concentric spheres, each revolving with its own uniform speed about a certain diameter as axis, and all having the fixed stationary earth as center. Of the twenty-seven spheres, one was for the fixed stars, three were for the moon, three for the sun, and twenty for the planets (four for each).

The single sphere for the fixed stars, revolving uniformly in twenty-four hours from east to west about an axis through the fixed earth as center, served to explain the apparent daily rotation of the heavens. The motion of the moon was thought to result from the combined rotations of three concentric spheres, with the moon itself fixed on the equator of the third and innermost sphere, while a similar triadic system of spheres accounted for the sun's "uniform motion."[4] Strangely enough the great circle which the sun supposedly traced on the third sphere was slightly inclined to the ecliptic itself. Planetary motion was still more ingeniously arranged, requiring four spheres. The planet itself was fixed on the equator of the fourth and innermost sphere, and, due to the motions of the third and fourth spheres, it described a ∞-shaped curve on the surface of the second sphere. The speeds of rotation and the poles of the four spheres varied for the different planets.

From the foregoing inadequate description, lest the reader might infer that the system was extremely complicated, it is pertinent to note that Eudoxus used but three elements in his planetary determinations where modern methods utilize no less than six. Moreover, a comparison of Eudoxus' values for the synodic and sidereal periods with modern ones,[5] suffices to show that his scheme was not purely fantastic.

	Synodic Period		Sidereal Period	
	Eudoxus	Modern	Eudoxus	Modern
Saturn	13 months	378 days	30 years	29 years, 166 days
Jupiter	13 months	399 days	12 years	11 years, 315 days
Mars	8 months, 20 days	780 days	2 years	1 year, 322 days
Mercury	110 days	116 days	1 year	88 days[6]
Venus	19 months	584 days	1 year	225 days[6]

When we realize that the geocentric theory was proposed more than twenty-three centuries ago, Eudoxus' achievement can scarcely be praised too highly. Certainly it represented a brilliant example of logical and geometrical ingenuity, and constituted a theoretically perfect scientific work.

[4] Assumption of uniformity in the sun's motion disregarded the inequality of the seasons, which had been observed several decades earlier.

[5] Heath: Aristarchus of Samos, p. 202; Dreyer: Planetary Systems, p. 88.

[6] Both Heath and Dreyer give values of 1 year in lieu of 88 days and 225 days.

Eudoxus made other significant contributions to astronomy. For example, he was the first Greek to give a description of the constellations and the first to propose a solar cycle of four years—three of 365 days, and one of 366.

III. Ecphantus (Ἔκφαντος) : ?

Very little is known of this astronomer, who flourished in the early part of the century. He probably belonged to the Pythagorean school, and may have been the first astronomer to suggest that the earth rotated about its own axis in an eastward direction.

Heath regards this astronomer as an exceedingly mysterious personality, and is inclined to think Ecphantus was but a nominal mouthpiece for Heraclides' views. (q.v.VII).

IV. Philip of Opus (Φίλιππος ὁ ὀπούντιος) : ?

This mathematician and astronomer was a true disciple of Plato, and a contemporary of Eudoxus. It is quite likely that he was also known as Philip of Medama. He was the recognized author of various works —none of which are extant—, the editor of Plato's "Laws," and a writer on astronomical subjects. He may have been the author of a treatise "On the size of the sun and the moon and the earth," and of another "On the eclipse of the moon"; in which case he might be regarded as the real predecessor of Aristarchus, later prominent as a mathematician.

Sarton[7] tells us that Philip of Opus wrote on polygonal numbers, and that he may have explained the rainbow as a phenomenon of refraction.

V. Callippus (Κάλλιππος) : c. 370 B.C. - c. 300 B.C.

Some thirty years after Eudoxus' theory was first published, his friend and pupil, Callippus of Cyzicus, attempted to test the theory by observations. Finding pronounced disagreements, he sought to improve matters by increasing the number of spheres in the original system. He accepted Eudoxus' explanations for Jupiter and Saturn, but assigned one extra sphere to each of the planets Mars, Venus, and Mercury.

As we have already seen, Eudoxus had assumed that the sun's motion was perfectly uniform, even though the inequality of the seasons had been detected at a much earlier date. To correct the discrepancy involved, Callippus introduced two additional spheres into the sun's triad —following the principle which Eudoxus had utilized in representing the synodic inequalities for the planets. In this way the sun's motion was then satisfactorily explained by the combined rotations of five concentric spheres.

In the case of the moon, Callippus' revision was effected by adding two more spheres, making five in all. Pending the discovery of that

[7] Sarton: Introd. to History of Science, Vol. I, p. 118.

perturbation known as evection,[8] the geocentric theory was then quite as adequate as any other to describe the moon's motion.

Callippus' changes represented a substantial improvement in the geocentric theory, and comprised thirty-four concentric spheres. They served to reconcile much of the theory with observational evidence, judged, of course, by the limits of accuracy obtainable at that time. In fact, Callippus' analysis of Eudoxus' system constituted a splendid example of scientific work, wherein theory and observation were recognized in their proper rôles.

Callippus was responsible for a great improvement in Meton's cycle, indicating that he must have had a precise knowledge of the length of the period of revolution of the moon. For Meton's soli-lunar cycle of 19 years, he substituted one of 76 years, thereby making the length of the year $365\frac{1}{4}$ days in lieu of Meton's 365 5/19 days. While these cycles of Callippus never came into general use, they were adopted by individual astronomers to fix dates.

Chronologically, we should probably have placed Callippus after Aristotle, but, since the latter's alterations of the geocentric system were made upon the former's work, we have reversed the order.

VI. ARISTOTLE (Ἀριστοτέλης) : c. 384 B.C. - c. 323 B.C.

Aristotle was born at Stagira, and was a pupil of Plato. We are told that he was extremely disappointed when he was not chosen head of the Academy upon Plato's death. This honor fell to Plato's nephew, Speusippus, who was a natural successor, perhaps, even though Aristotle was the logical one.

Around 335 B.C. Aristotle founded his own school, called the Lyceum or the Peripatos (the latter name being derived from a covered walk in which the lectures were given). The school lasted until the third century A.D., though much of Aristotle's teaching has survived to this day. This philosopher's work formed a veritable encyclopaedia, covering the entire field of knowledge in ancient Greece. It was essentially factual in character, and revealed that cautious critical temper, so typical of the true scientific attitude of mind.

It is no exaggeration to claim that he was one of the greatest men of science the world has ever known, and that "The prodigious activity of Aristotle marks the climax of the golden age of Greece."[9] His work in astronomy, however, is a poor index of his singularly worthy reputation in the positive development of many other branches of science.

Aristotle's metaphysical conceptions exerted an erroneous influence upon many of his considerations in cosmic astronomy, and as a consequence he adhered resolutely to the geocentric system. The overwhelming authority which succeeding generations attached to his teaching was

[8] Discovered by Hipparchus c. 150 B.C.; compare Sarton, p. 273.

[9] Sarton: Introd. to History of Science, Vol. I, p. 124.

largely responsible for the negative and apathetic reception accorded the heliocentric hypothesis later advanced by Aristarchus,[10] and certainly tended to retard subsequent progress towards the Copernican view.

Nevertheless, astronomy shared with all other science the tremendous benefits which were bound to result from the systematic and critical analysis and the experimental methods used in Aristotle's approach to scientific problems. As the so-called[11] inventor or father of logic, "Aristotle represented the maturity of Greek scientific development."[12]

Many of Aristotle's astronomical views were incorporated in the second of his four books "On the Heavens." Herein he discussed "the form of the Kosmos, the motions and nature of the stars, and finally the position and form of the earth which is at rest in the center of the universe."[13] We have already alluded to the fact that Aristotle's cosmological considerations led him to advocate and vigorously support the geocentric theory, thereby following his forerunner and teacher, Plato.

Since an intelligible survey of Aristotle's numerous astronomical ideas—constructive or otherwise—would require a great deal of space, we shall refer merely to two items of interest.

Primarily, he endeavored to improve the geocentric theory of Eudoxus and Callippus. Theirs was essentially an abstract, geometrical conception descriptive of the motions of the heavenly bodies; Aristotle attempted to transform it into a mechanical arrangement of spherical shells. To achieve his purpose he added twenty-two "reacting" spheres to Callippus' revised system, making the sum total of fifty-six! This change was far from an improvement, and only served to complicate and impair the original structure.

Secondly, his explanation of comets and the Milky Way is worthy of mention, since it was sanctioned amongst eminent astronomers until Newton's time. Briefly, Aristotle postulated that comets and the Milky Way were mere atmospheric phenomena. That this view was retained for so long, despite Seneca's[14] rational arguments to the contrary, furnishes another illustration of the overwhelming influence attached to Aristotelian doctrines.

Generally speaking, many of Aristotle's astronomical discussions are of great value, not because of the intrinsic merit of his own views, but because of the knowledge and criticisms they contain concerning the opinions held by earlier astronomers.

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[10] c. 310 B.C. - c. 230 B.C.
[11] See Enriques: Historic Development of Logic, p. 4.
[12] Windelband: History of Ancient Philosophy, p. 249.
[13] Dreyer: Planetary Systems, p. 109.
[14] c. 4 B.C. - 65 A.D.

VII. HERACLIDES OF PONTUS (Ἡρακλείδης ὁ ποντικός): c. 388 B.C. - c. 315 B.C.

The most original astronomer to flourish during the latter half of the century was Heraclides,[15] a pupil of Plato's Academy, and possibly of Aristotle's Lyceum. From his teachings we might also infer that he was associated with the later Pythagorean school as well. In any case, he was essentially an independent thinker, and had sufficient courage to proclaim views which were at variance with the accepted Aristotelian teaching.

Heraclides wrote on a very large number of diverse subjects, but all his writings have been lost. So far as his astronomical work is concerned, his reputation rests largely upon two remarkable contributions to this science.

In the first instance, he fearlessly espoused the doctrine of the earth's rotation on its axis. Whether or not Ecphantus had thought of this earlier is by no means certain; it is generally recognized, however, that Heraclides did advance this conception in a clear and persuasive manner. The importance of this hypothesis is best appreciated when we consider what a tremendous departure from the traditional view was involved. The earth had been regarded as stationary, and the daily motion of the celestial sphere was supposed to be a real motion of the sphere itself. Heraclides' conception was a direct reversal of the accepted one, for he maintained that the apparent diurnal rotation of the heavenly bodies was caused by the rotation of the earth about its own axis, while the celestial sphere remained at rest.

His second great achievement was the discovery that Venus and Mercury revolved around the sun as center. Actually, there are commentators who regard Heraclides as the true precursor, not only of Tycho Brahe, but of Copernicus as well. However, Heath and Dreyer both consider such claims to be exaggerated and unwarranted.

While these two doctrines of Heraclides were extremely important in themselves, they should be recognized as unusually significant, inasmuch as they were both opposed to the teachings of the time. Surely it is to his credit that he dared to proclaim ideas so far removed from the authoritative sanction of Aristotle's philosophy.

VIII. AUTOLYCUS (Αὐτόλυκος): flourished c. 310 B.C.

Amongst the contemporaries of Aristotle was the astronomer and mathematician, Autolycus of Pitane. He wrote two astronomical books which have been preserved. The first of these deals with motion of the sphere, and consists essentially of twelve propositions concerning the principal circles. The second discusses risings and settings of the fixed stars. Both books were later included in the Little Astronomy, of which a manuscript is in the Bodleian Library at Oxford.

[15] Turner, A. W.: *ibid.*

Autolycus appears to have been the first astronomer who tried to meet the rather obvious deficiencies in the geocentric theory. We recall that the system supposed the planets to be on the equators of concentric spheres, having the earth as center. Clearly, this hypothesis implied that the brightness of a planet would be invariant to an observer on the earth. However, even casual observations of the varying brightness of the planets—especially of Venus and Mars—showed the theory untenable when tested by this criterion. The apparent differences in the sizes of the sun and the moon presented a similar anomaly between theoretic formulation and observed fact. Naturally, under such circumstances, Autolycus' attempts to account for the discrepancies were destined to fail.

Unfortunately, very little is known of his personal history.

Conclusion

There is little doubt that many of the fundamental facts of modern astronomical teaching were known to the astronomers of the fourth century B.C. Moreover, they appreciated the necessary mutual relation between theory and observation, as disclosed by their persistent attempts to improve the geocentric theory.

Perhaps all beginnings in science are obscure, and the subsequent growth destined to be unsteady and slow. During the fourth century B. C., however, scientific astronomy was bravely trying to solve great cosmic problems. The history of this period is eminently worthy of the splendid subject to which it belongs.

Dominion Observatory, Ottawa, Canada, November, 1935.

The Simpler Aspects of Celestial Mechanics

By HOMER A. HARVEY

(Second Paper)*

We have described the horizon as a purely local phenomenon and unique for any given spot upon the earth's surface. There remain to be mentioned two more "sky-marks" to complete the observer's local frame of reference.

The Meridian

This most important sky-mark may be defined for the moment as that curved line upon the starry dome which begins at the south point of the horizon, passes directly overhead and ends at the north point of the horizon. Strictly speaking, the remaining half of this curved line, bisecting

*The first paper appeared in the February (1936) issue of Popular Astronomy.

the invisible hemisphere of sky beneath our horizon, is also a part of the meridian, but we are not ordinarily concerned with it. The meridian divides the dome of the sky above the observer's horizon, as well as the portion beneath it, into halves. For any celestial object which rises and sets it constitutes the halfway point of its excursion.

The Zenith

This is the point directly overhead in the hemisphere of the heavens above our horizon. It lies upon the meridian and is equidistant from all points upon the horizon.

The three sky-marks thus far described, ***horizon, meridian,*** and ***zenith,*** constitute a triad unique for the observer, and follow him to any station he may assume upon the earth's surface.

The Celestial Sphere

This hollow sphere, of which we see one-half from any given point upon the earth's surface, ignoring irregularities in the visible horizon, is an optical illusion, and has no existence in reality. By reason of this illusion all celestial objects, from our nearest neighbor, the Moon, to the most distant nebula millions of light years from our earth, appear to lie upon the surface of this dome at a uniform distance from us. This apparent sphere may be best thought of as turning continuously westward, about an axis of which the earth's axis is a segment, *over* the local framework just described. Its apparent motion is the sum of two motions arising from two independent causes; a ***diurnal,*** caused by the rotation of the earth upon its axis, and apparently carrying the sky completely around us in about four minutes less than 24 hours, and an ***annual,*** caused by the revolution of the earth in its orbit, and which, superimposed upon the daily motion, explains the slow westward drift of the heavens day by day with reference to the sun, with which even the casual observer is familiar. This drift, amounting to a complete circuit in the course of a year, is thus somewhat less than four minutes a day ($24 \text{ hr.} \div 365\frac{1}{4} = 3 \text{ m } 55 \text{ sec}$). The movement of the celestial sphere, as well as the sphere itself, is also an illusion, and is to be comprehended only by analyzing its causes independently, and without admitting to court the evidence of our own senses. Upon our grasp of this fundamental mechanism will depend the mastery of the motions of the heavenly bodies. The amateur will presently come to have respect for the fantastic attempts of the ancients to reconcile what they saw with some sort of orderly geometrical plan of the solar system, for he will find that even with the key to the riddle in his hand, he will still have no little difficulty in visualizing the true relationships. Further discussion of this matter we may postpone to an appropriate time.

Upon the celestial sphere are two more sky-marks which, while also unique for a given observer, in that they bear a constant fixed relation to the rest of his framework, are nevertheless common to all observers,

wherever located. As distinguished from the horizon, meridian, and zenith, these markings occupy a definite position among the stars. These are the Celestial Poles and the Celestial Equator.

The Celestial Poles

These are the points upon the celestial sphere at which the earth's axis, produced outward into space, penetrates it. Usually only one pole is visible at a time, though a person standing upon the equator could see both poles simultaneously, upon his north and south horizons. Since the axis of the earth preserves a practically constant position in space with respect to the stars, it follows that the celestial poles are fixed points among the stars upon the celestial sphere. The north celestial pole, with which the great majority of our readers will be concerned, lies very near the star Polaris, and about this point, therefore, the heavens of the observer in the northern hemisphere will appear to rotate with a motion equal to the two combined motions described.

An observer at the north pole would see Polaris directly over his head; his latitude and the elevation of Polaris above his horizon are alike 90°. Similarly, an observer upon the equator would see Polaris upon his northern horizon; his latitude and the elevation of the celestial pole both being equal to 0°. We may now announce an important principle in astronomy, viz:

The latitude of the observer is equal to the elevation of the celestial pole above his horizon

and prove it by means of the following figure.

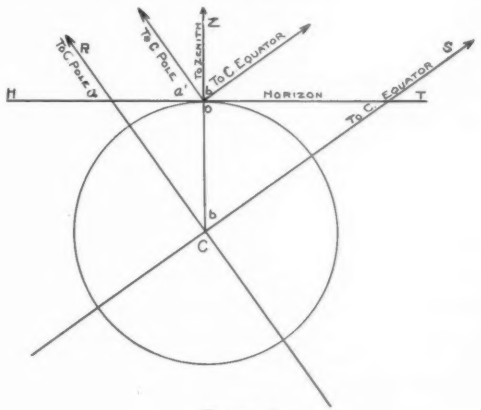

Figure 1

Angle *a'* (elevation of pole) equals Angle *b* (latitude).

Let the observer be at O, and the center of the earth at C. The observer will then see the celestial pole in the direction indicated, at the

angle a' above the horizon, and the zenith along the line OZ, perpendicular to the horizon HT. CR, the earth's axis, is perpendicular to CS, the equatorial plane.

Since the sides of angle a, CR and HT, are respectively perpendicular to the sides of angle b, CS and CZ,
Therefore, angle a = angle b.
But angle a' = angle a (corresponding angles of parallel lines).
Therefore angle a' = angle b (observer's latitude). Q.E.D.

The Celestial Equator

The second sky-mark, the celestial equator, will also be made clear by the same figure. If we produce outward the plane of the earth's equator it will cut the celestial sphere in a great circle of that sphere. This circle will be depressed from the observer's zenith by an angle equal to the latitude, and every point upon it will be 90° from the celestial pole. Its visible half will begin at the east point of the observer's horizon and end in the west point, and will therefore cross his meridian at right angles, and will in turn be bisected by it. A special case of this statement arises for an observer at either pole, in which case the celestial equator will coincide with his horizon.

Thus it will be seen that the celestial pole and the celestial equator occupy constant fixed positions with respect to the observer's framework. If his station be, for example, 43° N latitude, the pole (Polaris) will be 43° above his northern horizon, and the celestial equator depressed an equal amount from his zenith. The student must by all means, however, avoid thinking of carrying these sky-marks with him as he shifts position, as in the case of his horizon, meridian, and zenith, since they both have a *fixed position* among the stars. As the observer changes *latitude* they will assume corresponding positions upon his framework, in accordance with the principles laid down. Change of *longitude* will produce no effect, as will be seen upon a moment's reflection. The celestial pole and equator must be thought of therefore, as drawn upon the *moving* sphere which slips continuously westward over the observer's local framework.

Since the whole of the starry heavens rotates apparently about the celestial pole, it follows that *the paths of all fixed celestial objects across the observer's sky must be in or parallel to the celestial equator.* The sun, moon, and planets, since they are constantly altering their apparent position among the stars, conform only approximately to this rule, because between rising and setting they may either increase or diminish their distance from the celestial equator.

It also follows that all stars lying within a distance of the celestial pole equal to the elevation of the pole above the horizon—in other words, equal to the observer's latitude—will describe daily circles above it whose whole circumference will be entirely above the horizon. All celestial objects lying farther than that from the pole will describe *arcs* in the sky and hence will rise and set. Similarly, there will be a circle

about the south celestial pole with a radius equal to the observer's latitude within which stars are forever hidden from him. Thus Canopus, a conspicuous object in the tropical sky, cannot be seen from these latitudes, since it is only 37° from the south celestial pole.

Lastly, it should be apparent to the student that a celestial object which in its diurnal excursion just touches the northern horizon will remain above it for the full 24 hours, and that for objects farther and farther away from the pole this time grows less and less until it becomes zero upon the "Circle of Perpetual Occultation" about the south pole. Objects upon the equator will be above and below the horizon equal times, since it has already been pointed out that the horizon divides the circle of the equator into halves.

Since the longest possible diurnal star-path upon the celestial sphere is the equator, it follows that celestial objects lying on or near it apparently move the fastest, and that this rate diminishes for stars nearer the poles, where the diurnal circles become smaller, because the daily excursions of all stars alike are accomplished in the same time. This relationship may be expressed as follows:

The apparent rates of motion of celestial objects are to each other as the cosines of their angular distances from the Equator (Declination).

Thus, if a star upon the equator crosses the field of a telescope in 3 minutes, one 32° north of the equator will cross only about 85% of the field in the same time (since $\cos 0° = 1$ and $\cos 32° = .84805$). It will require $3^m\ 31^s$ to cross the whole field.

The following figure will illustrate the foregoing principles.

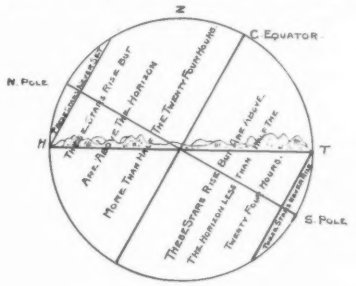

FIGURE 2
HT, HORIZON; Z, ZENITH.

One more sky-mark must now be described. As in the case of terrestrial geography, some great circle must be selected as the origin of reference for defining the position of celestial objects in the eastward and westward directions upon the celestial sphere. For this purpose the great circle passing through the "Vernal Equinox" is selected. Any other hour-circle would do just as well, if the astronomers so agreed,

just as upon the earth the meridian of Chicago, Illinois, would be quite as satisfactory as that of Greenwich, England, if there were a unanimous understanding to that effect. The Vernal Equinox will be more fully defined later; for the present suffice it to say that it is a point upon the celestial equator in the constellation of Pisces.

Right Ascension and Declination

We are now in a position to define accurately the position of any object upon the celestial sphere. Astronomers use the term *Declination* to indicate angular distance north or south of the celestial equator, except that + and — are used, as a rule, instead of north and south, respectively, as in the case of its geographical analogue, latitude. Thus, a star with a declination of —16° 37′ 30″ would lie upon a circle parallel to the celestial equator and that angular distance south of it. A second locus, perpendicular to the first, would fix the position of the star. This is furnished by the *Right Ascension*. It may be defined as the angular distance *eastward* from the vernal equinox, measured in *hours, minutes, and seconds,* along the celestial equator to the foot of the hour-circle passing through the star. If now we further specify that the right ascension of the star in question is $6^h\,42^m\,15^s$, we have defined the second locus—the star is somewhere along the hour-circle indicated by the given right ascension. The intersection of the two loci indicates the exact position of the star; the coördinates given are those of the Great Dog Star, Sirius, and it is located at this point upon the celestial sphere.

The American Ephemeris and Nautical Almanac, obtainable from the Government Printing Office for a small sum, will supply the coördinates of most of the principal stars, as well as those of the Sun, Moon, and Planets—the stars requiring one set for the entire year, while the moving objects require daily, and, in the case of the moon, even hourly figures for their exact location. The student would do well to obtain at the outset this volume, as we will have from now on frequent occasion to refer to data given in it. It is the astronomer's indispensable ally, and will become more and more fascinating to the amateur as his knowledge of celestial mechanics expands.

Unfortunately for the beginner, the hour-circles and parallels of the celestial sphere are not conveniently drawn and numbered upon the sky, and so he must resort to some kind of instrumental means of locating the axes of reference and the coördinates built upon them. Even with the invaluable information in the *Ephemeris* he is helpless as before unless he can locate the celestial equator and the vernal quinox. If he has a telescope, he can of course mount upon it right ascension and declination "circles" which will enable him to locate readily any object in the heavens. The ambitious amateur will eventually have such a telescope, even though it be a small one. The setting-up of such an instrument will be discussed later. If for the present he has no telescope and must perforce do his observing with the naked eye, he can at least obtain a

"Star Finder" provided with circles for the use of coördinates. The best of these, in the opinion of the writer, is the Kullmer Star Finder, the cost of which is trivial and which raises amateur astronomy at once from star-gazing to an exact science. A good star-map is an excellent adjunct to the *Ephemeris;* Schurig's *Himmelsatlas* is cheap and accurate. (Brentano Book Store, New York City, can get it from the German publishers.)

Questions and Answers

1—What is the elevation of Polaris at Rome, Italy? About 42°.

2—At Leningrad, Russia? About 60°.

3—At Johannesburg, South Africa? About 26° *below* the horizon.

4—On March 21 the sun is on the celestial equator. What is its course on that day for an observer at the North Pole? Remains on the horizon all day, swinging around the complete circuit.

5—What is the elevation of Polaris as seen from the Arctic Circle? 66½°. What is the course of the sun as seen from a station on the Arctic Circle on June 21 (i.e., when its declination is +23½°)? Touches the northern horizon at midnight, thence swings in a circle whose plane makes an angle of 23½° with the plane of the horizon, and crosses the meridian 43° south of the zenith. The Arctic Circle is the most southerly parallel at which it is possible to see the sun for the whole 24 hours (theoretically, for acutally refraction extends the limits southward).

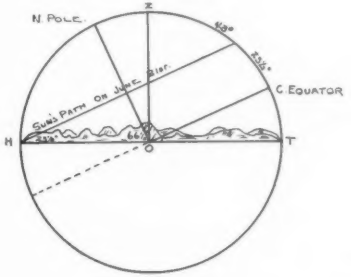

Figure 3

Conditions at Arctic Circle on June 21. Observer at O.

6—What is the daily course of stars for an observer at the equator? All celestial objects move in arcs perpendicular to the horizon.

7—What length of time are stars above and below the horizon for an observer at the equator? 12 hours each. The same, of course, is approximately true for the sun; hence day and night at the equator are always about equal, regardless of the time of year (neglecting refraction).

8—What is the daily course of Polaris for an observer at the equator? If Polaris were exactly at the North celestial pole it would lie continuously upon the northern horizon. Actually it describes a circle about 2° in diameter about the pole.

9—What is the course of the sun on December 21 (declination —23½°) for an observer at the North Pole? It moves parallel to the horizon, which at this station coincides with the celestial equator, and 23½° *below* it. There is, therefore, complete darkness, since twilight occurs only when the sun is not more than 15° below the horizon. By reference to the *Ephemeris* it is seen that the sun reaches this declination on February 9, and hence dawn at the North Pole begins on that date, growing gradually brighter until March 21, when the sun reaches the equator and appears on the horizon.

10—From what station on the earth is it possible to see all visible stars in the sky? The equator.

11—How large is the Circle of Perpetual Occultation for an observer at the North Pole? The whole southern hemisphere of stars.

12—What is the farthest northern latitude at which it is possible for the sun to pass through the observer's zenith? Tropic of Cancer; at this latitude the celestial equator is depressed from the zenith 23½°. On June 21 the sun's declination is plus by the same amount. Hence it will pass through the zenith.

13—Picture the conditions at Stockholm, Sweden, on June 21. On that day the sun is 23½° north of the celestial equator. At the latitude of Stockholm the celestial equator is depressed from the zenith 60°, and hence the invisible half is depressed below the northern horizon by the complement of 60°, i.e., 30°. Therefore, at midnight the sun will be 6½° below the northern horizon. It moves along a short arc below the horizon between sunset and sunrise, so that actual night lasts only a few hours, and since the sun never sinks below the twilight limit, there is twilight all night. As a matter of fact, one can read a newspaper at midnight. This phenomenon, occurring on or near the Arctic Circle, is popularly known as the "Midnight Sun."

14—Picture conditions in Stockholm on December 21. On that date the sun's declination is 23½° south of the celestial equator. Hence at *noon* it will cross the meridian 6½° above the southern horizon. Daylight will therefore last the same length of time as did night on June 21. There is a zone of twilight at each end of the short day which prolongs it by a considerable amount, since the path of the sun being at an acute angle to the horizon, a longer time is consumed in reaching the twilight limit of 15° below it. The celestial equator, as shown, is 30° below the northern horizon at Stockholm; hence the sun will be 53½° below the northern horizon at midnight.

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Terminology in Meteoritics

By H. H. NININGER*

ABSTRACT

A survey of the literature reveals many inconsistencies in the use of terms relating to meteorites and meteors.

Mr. Nininger finds eleven different meanings assigned to the word meteor by different writers of prominence and often the same writer using the words meteorite and meteor inconsistently.

He points out that meteoritics is a borderland science growing out of astronomy, geology, and mineralogy, and that the resultant lack of contact among the various writers is to some extent responsible for their inconsistencies. Attention is also called to the lack of a term by which to designate those who make the study of meteorites a profession.

The word meteorite he finds to be well established as the name applied to masses of solid matter fallen from space to the earth. This word is also used to designate this same matter while still in space. A smaller number of writers apply the term to the burning missiles while they are falling.

Conflicts are best avoided by those who distinguish between meteorites as material substance and meteors as the light phenomena produced by meteorites during their flight through the atmosphere.

Clear and concise use of language is essential in any body of literature if it is to be effective. Consistency and uniformity in the use of technical terms is equally essential in any field of science.

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In almost every instance, however, as new sciences have developed there have arisen conflicting or diverse usages of terms. This is the natural result of different workers pursuing their individual courses independently. Such conflicts do not merit severe criticism; but there comes a time when for the best interests of science, an effort should be made on the part of all those concerned, to bring about a satisfactory agreement upon definitions of terms.

The literature relating to meteorites and meteors has suffered even more perhaps, than has been the case in many other fields, for the reason that until recently there has been no attempt at unification of effort through an organization and also because this field is a sort of no-man's land between astronomy, geology, and mineralogy. This condition gives less cause for contact among various workers than is the case in most sciences. Accordingly, we find a wide variation in the use of certain terms by various writers in the field. This lack of unity places an unjustified burden upon the amateur as well as upon the professional student of meteorites.

The Society for Research on Meteorites, recognizing the need along this line, appointed a committee on terminology on the occasion of its first annual meeting in Chicago, August, 1932. This committee has had one meeting and considerable correspondence regarding the problems which face it in the bringing of recommendations regarding the usage of terms.

This paper is not a report of that committee but is rather a presentation of certain findings which have been brought together out of a rather extensive review of astronomical, geological, and meteoritical literature. It is by no means a complete survey of the literature and the plan is to extend it as opportunity is afforded. This preliminary report on this research is presented in order to bring before scientists the problems which face our committee, and to present a plan of investigation which we feel should serve as a background for our future action. It is hoped that this presentation will stimulate others both within and without the committee to send in to us reports of usages employed by writers other than those named in our bibliography and thus assist the committee in making the best possible recommendations.

In going through the literature we were impressed with the following facts: (1) There are several terms, each of which is used with different meanings by different writers. (2) There are certain terms which are used inconsistently even by the same writer. For example, the term meteor is defined by some writers as cosmic particles which enter the atmosphere but do not survive to reach the soil, in contrast with meteorites which are found. Yet these same writers are found later discussing the "meteors" in our museums. In some cases this was found true of scientists of international reputation which indicates that the subject has been grossly neglected. (3) We find the literature completely lacking

a term to designate those persons for whom the study of meteorites is a profession.

Confusion in the use of terms such as we point out in this paper is unfortunate, to say the least, and its continuance seems inexcusable. It is hoped that after proper deliberation and research our committee may bring recommendations which will meet with general approval in the Society and throughout the ranks of workers in the field of meteoritics.

The author of the present paper has followed the method of systematically exploring library shelves on astronomy, geology, and meteoritics. The index of a book is consulted and all references to such words as meteor, meteorite, meteoritics, meteoroid, aerolite, uranolith, comet, etc., are read and noted. Then these notes (usually in the form of quotations) are classified according to the usages employed by each writer. In this way it is possible to ascertain what usages prevail in regard to the different terms.

In thus surveying the literature we find that there is almost unanimous agreement that a solid body of ponderable size, which has fallen from space through the atmosphere and landed on the earth, shall be called a *meteorite*. There are, however, a few who would require that it be found by man before it is entitled to this designation. There are also some few who would use the term *aerolite* for such bodies and who find no need for the term meteorite. With a decidedly large majority of writers, however, *meteorite* is a word well established as applied to fallen masses of matter.

With not so many, does the term meet with favor as a designation for these same masses while out in space. Only thirty of the authors consulted specifically refer to meteorites in space. Some others imply such a meaning but no instance of its actual use was noted in their writings which we consulted. Among these thirty, however, were such prominent names as Lockyer, Lowell, Howe, Pickering (W. H.), Newton, Campbell, Chamberlin, Moulton, Ball, Farrington, Chladni, Gregory, Reichenbach, Tait, Turner, Cleland, Tarr, Schiaparelli, Zittell, Gore, Doubleday (Dictionary), Fletcher, and others. With such an array of noted contributors to our science favoring this use of the term for matter in space, we could hardly refuse it our endorsement even if we held a prejudice against it.

If we follow the visitors from space on their journey through the atmosphere we shall find that not so many writers are willing that they shall carry their spacial cognomen with them to their terrestrial abode. Only a dozen of the thirty noted contributors, referred to above, definitely insist upon the earth-bound immigrants bearing their spacial label while engaged in their deadly conflict with the enemy friction as they pass through the atmosphere. The others prefer that this title be laid aside at the outer fringe of our aerial blanket and resumed again upon their contact with *terra firma*. They would designate the warring travelers with the term *meteor*.

The group who prefer to have these bodies bear the name meteorite in all three situations, namely, in space, during flight, and on or in the soil, also accept the term meteor as applicable during the atmospheric struggle; but they apply it to the light phenomena which this struggle produces and still allow the intruder himself to bear his extra-mundane title which he seems obligated to resume again anyway after he takes up his terrestrial residence.

Some there are who are willing to have the arrivals bear the name *meteorite* throughout their aerial conflict provided they are large enough to survive the said conflict and make a landing; but for those which are entirely dissipated during flight some other name must be applied, as bolide, fireball, meteor, or shooting star. This group (mostly astronomers) is represented by the late Dr. Willard J. Fisher, who subdivided meteors into groups as follows: (1) "*shooting-stars*"; (2) "*fireballs* or *bolides*"; (3) "*picked-up meteors* called *meteorites*." Dr. Chas. P. Olivier adopts essentially the same usage.

These men would doubtless have a larger following in their nomenclature but for the difficulty we have in knowing which of the large meteors are going to survive. If we adopt their terminology we could wait to see whether a fall is found or not; but this leaves us unsettled for years and in many cases it would never be possible to decide whether a particular "meteor" should be regarded as a meteorite or not, for the simple reason that we could never prove that the meteorite which was picked up, if one were picked up, was the one seen to fall. Dr. Olivier himself admits that probably a hundred meteorites fall for every one that is found. He recognizes this problem and admits that it is difficult to know which to regard as meteorites among the fireballs witnessed. But he seems willing to allow the matter to stand in this unsettled manner. He leaves it up to us to guess as best we can.

Farrington, Lockyer, and the rest of their group have solved this problem by making a distinction between meteorites as material substance and the light phenomena which they produce while falling through the atmosphere. They are never in doubt about a meteorite being present where they see a meteor, however large or small. They speak of the light phenomena as a meteor in all cases. They speak of meteorites as tangible objects on the earth, as matter in space, or while falling through the air. But for this group no one ever sees a meteorite while falling unless it is some one near enough to see the black object approaching the earth after the light—the meteor—has been extinguished.

Olivier, in his book "Meteors" p. 242, refers to the great meteoric procession of February 9, 1913, as "the most remarkable procession of meteorites ever observed as such." Here he is inconsistent in the light of his own definitions given on page 7 of the same book. There he states that the only difference between a meteorite and other great fireballs is that the meteorite must survive to reach the ground. In the case

referred to, the procession passed out to sea and no one can ever know with certainty whether any or all of those bodies which occasioned that display came to rest on the earth or not. For the other group of writers, it is entirely consistent to discuss the *meteorites* which occasioned the display, or the *meteors, which were* the display. Their discussion can be perfectly clear in either case.

It was such inconsistencies as these just mentioned which led the author of this paper to preface his treatise "Our Stone-Pelted Planet" with definitions of the three important terms: *meteor, meteorite,* and *meteoritics.**

There is also some indefiniteness in all the literature regarding the term meteorite in another respect, namely, it is commonly used either to designate a stone which constitutes a complete fall, a meteorite shower, or an individual fragment of a fall. In other words a meteorite may be, according to the literature, a mass which has fallen from space, a fragment which has resulted from a disruption of the parent mass during its flight through the atmosphere or an entire shower of such fragments. Here some writers have attempted to avoid the difficulty by the use of the word bolide for the individual stones of a shower. Bolide is more often used, however, as a designation for detonating fireballs.

Still another difficulty presents itself in connection with meteorite showers. That the ordinary multiple fall has resulted from the disruption of a mass during flight seems to be well established. But there is also good reason for the belief that in some instances meteorites enter the atmosphere as groups or systems. Probable examples of this condition are the groups of meteorite craters near Henbury, Australia, and the lately discovered Carolina Scars, both of which are thought of as having resulted from the impacts of comets, or swarms of meteorites. It is also probably true that some of our smaller showers result at least in part from miniature swarms encountering the earth.

According to the accepted practice in describing meteorites, all of the individual stones or irons of a given fall are regarded as belonging to the same meteorite as stated above. To simply mention a fall as a shower fails to distinguish between those entering the air as a swarm and those merely arriving on the soil as a shower. In the light of recent discoveries we have need here for a new term. Perhaps *meteorite system* or *meteorite swarm* would be suitable. Comet would hardly seem applicable in cases of such small swarms as probably give rise to some of the showers of this type.

The term *aerolite* is used by quite a large number of writers as a

*Our Stone-Pelted Planet, page preceding introduction: Meteorite: A mass of solid matter, too small to be considered an asteroid; either traveling through space as an unattached unit, or having landed on the earth and still retaining its identity.

Meteor: The light phenomena occasioned by a meteorite flinging into the earth's atmosphere from space.

Meteoritics: The science of meteorites and meteors.

synonym for meteorite. By a smaller number it is used as a substitute for the term meteorite and the latter term not used at all. Its widest usage, however, is as a designation for meteorites of the stony variety as distinguished from metallic forms which are known as siderites.

The greatest confusion comes in the use of the word meteor. This term is used by different writers with meanings as follows:

1. The light phenomena occasioned by the plunging of a meteorite into the earth's atmosphere.
2. Any luminous particle while falling through the atmosphere.
3. Only those luminous particles of small size which are popularly known as shooting stars and which are visible on any clear night.
4. Larger than ordinary shooting stars, synonymous with fireball.
5. Larger than fireballs, detonating and yielding meteorites.
6. Invisible particles in space which become luminous upon encountering the earth's atmosphere. Some of this group of writers also regard meteors as making up the nuclei of comets.
7. Not a few use the term as synonymous with meteorite and some as a substitute for it. These refer to the analyses of meteors and our collections of meteors in museums.
8. Olmsted and Snell subdivide meteors into gaseous and solid meteors. Solid meteors of large size may yield aerolites according to these authors.
9. Maunder gives as one definition of meteor, "any light in the sky." This is also a dictionary definition.
10. A rather popular concept is that a meteor is similar to but larger than a meteorite.
11. Some regard any falling body as a meteor. And even though it actually makes a landing it is not a meteorite unless found by man.

With this formidable array of definitions there is little wonder that we find confusion as a major obstacle to progress in the development of our science of meteoritics.

This brings us to the consideration of the term *meteoritics*. So far as we were able to find, the noun meteoritics was first suggested as a designation for the science of meteorites by Dr. O. C. Farrington in 1915. In recent years it has come into rather common usage among those most concerned with this field of study and bids fair to be generally adopted. Though Farrington never wrote a formal definition of the term so far as we know, his book, "Meteorites, Their Structure, Composition and Terrestrial Relations," in which this name was proposed, would seem to fairly define the term. Accordingly, the present writer defined the term in "Our Stone-Pelted Planet" as the *Science of Meteorites and Meteors.*

This word is at present in common usage in the papers which are appearing from the most active workers with meteorites. It is defined in the 1934 edition of Webster's Dictionary, published by G. and C. Merriam Company, as "the science which treats of meteorites." It seems

therefore that this term is now established.

The adjective *meteoritic* has been in use for many years by Lockyer, Gore, Farrington, Chamberlin, Nininger, Leonard, and others.

The term *meteoritical* has been recently suggested by Dr. Frederick C. Leonard, President of the Society for Research on Meteorites, as a suitable adjective derived from the noun meteoritics. It seems a logical development and since the noun meteoritics has apparently become established it is probable that this adjective will in due time be accepted.

The term *meteoroid,* while of long standing and in our best dictionaries, seems to be very little used in recent years. It is defined as "one of countless small bodies in the solar (and likewise the stellar) system, which become meteors on entering the earth's atmosphere." This definition dates back to the time when the relation between meteors and meteorites had not yet been established. Apparently, therefore, when it had once been definitely proven that meteorites and meteoroids were the same bits of matter except for such reduction of size as the former had suffered while passing through the atmosphere, the intangible "meteoroid" came to be the more tangible "meteorite." At any rate we now find but a very few writers using the term, while references to meteorites in space are very common, particularly among the more recent writers. Some of the prominent astronomers who refer to meteorites in space are Lockyer, Gore, Lowell, Howe, Ball, Campbell, Newton, W. H. Pickering, and Moulton. Geologists even more universally adopt this usage.

Bolide is another word on which it seems there is some confusion though it is not much used. It seems to be used with about equal frequency to designate large exploding meteors or individual meteorites which have landed on the earth—especially the individual stones of a shower. Several astronomers specifically define it as an exploding or a detonating fireball.

Fireball is another loosely used term. It is defined by Olivier as "a meteor of at least the brightness of Jupiter or Venus or even several times the brightness of the full moon." This allows abundant latitude for the use of the term and it shall probably always remain a loose term for popular writing only.

Uranolith has been used by some as a synonym for meteorite. This usage was found only in a few cases and for the most part in older writings.

The adjective *meteoric* is a very widely used term and not always with the same meaning. As is well known, this adjective is properly used by geologists in referring to ground water; by meteorologists in referring to various atmospheric phenomena such as winds, clouds, lightning, etc., and by the medical profession in referring to excessive gas developments in the intestinal tract. In the latter field the noun meteorism is more often used.

We all know that in popular writings our science is incorrectely re-

ferred to as meteorology. The writer has perhaps been more often introduced as a meteorologist than by any other title, and, despite all explanations and arguments to the contrary, he yet receives twice a month from the treasurer of a certain museum a check with a receipt attached calling for his signature as meteorologist. This confusion will continue in popular writings for a long time to come. All of us are aware of it and we can do nothing better at present than to harmonize our own usage of terms.

There is no virtue in our resenting the use of the root word meteor and its derivatives by the group of scientists who study the weather. Their rights to these terms were established by abundant usage long before our science was born and, however illogical it may seem in the light of modern developments, that usage will probably never be abandoned by a department of research whose printed literature runs into thousands of titles. In fact the term meteor as first applied to the group of phenomena which we now study was applied in its literal Greek meaning as "of the air." The early students of these phenomena had no idea that they represented the infall of solid matter to the earth. They regarded them along with lightning, clouds, the aurora, etc.

"Meteoric astronomy" is a well established usage, and as applied to the astronomical aspect of meteoritics bids fair to continue in good favor. But meteoritics is as much a part of geology or mineralogy as it is of astronomy. This fact became known when first it was discovered that matter fell to earth accompanying some of the meteors which had been previously regarded as being only "of the air."

It seems probable that there is less danger of confusion when the adjective meteoric is used only in connection with the aerial display produced by the infall of matter. The writer is aware that the late Dr. Geo. P. Merrill, who was one of the most prolific writers on meteorites during the past generation, frequently made use of this adjective instead of meteoritic. Many other writers have done the same thing; but surely if we accept the noun meteorite we are obliged for the sake of consistency to adopt the adjective meteoritic. This work was abundantly established, if not earlier, then certainly by its appearance in 1890, in the title and text of Sir Norman Lockyer's monumental work on the meteoritic Hypothesis.

The late Dr. O. C. Farrington considered that the word meteor should properly be applied to the light phenomena which accompany the fall of meteorites. Where this usage is adhered to the writer has found less ambiguity than in those writings in which any of the other ten definitions of *meteor* are used. If an agreement could be reached on this definition by all writers, there would appear to be a good prospect of eliminating from future writings on the subject such confusion in the use of terms as prevails at present.

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Equipment for the Visual Study of the Sun at Whitin Observatory, Wellesley College

By JOHN C. DUNCAN, *Director*

The installation of a Hale spectrohelioscope at the Whitin Observatory was completed in October, 1934. It is of the usual type and dimensions, having a plane grating with a ruled surface of $2\frac{1}{2}$x3 inches, concave spherical mirrors of 13 feet focal length, line shifter, and Anderson rotating prisms before the slits. The grating, of 15,000 lines to the inch, is ruled in such a manner as to throw most of the light into one first-order spectrum.

The instrument is mounted horizontally in a basement room, the unit which contains the slits and grating being supported on a steel bracket fixed to the stone foundation of the building, and the casting which holds the two concave mirrors being mounted on a concrete pier. It is "fed" with sunlight by a heliostat which is mounted on the roof of the one-story building, the beam passing down a vertical brass tube through the ground-floor room and being reflected at right angles by a plane mirror at the level of the first slit. The image of the sun is formed on the first slit by a simple crossed lens of 5 inches aperture and 18 feet focal length which is contained in the upper part of the tube. At a convenient height above the ground floor a plane mirror is mounted in such

a way that it may be swung into the light-beam to reflect it through a window in the tube into the room, where the light may be used by elementary students in their laboratory work; when the spectrohelioscope is in use this mirror is of course swung back out of the way.

The first flat mirror of the heliostat, an ellipse 5x8 inches in size, is mounted equatorially and reflects sunlight up its polar axis to the second flat, which is fixed in such a position as to send the light vertically into the image-forming lens. The first mirror is driven at the solar rate by a motor of the Telechron type and may be given quick motion by other motors for setting in hour angle and in declination. The heliostat is protected from the weather by a dome of aluminum which, by a motor within the dome, may be tilted back on hinges attached to its flattened north side, the opening being sufficient to admit the sun's light at any time of the day or year. The motors operating the heliostat may be controlled from any of three sets of switches located respectively on the roof, in the ground-floor room, and near the eyepiece of the spectrohelioscope. The control-switch of the dome motor is in the ground-floor room, and that of a motor which raises and lowers the lens for focussing is in the set near the eyepiece.

The advantage of a heliostat over the usual coelostat consists in the simplicity of its operation, which may be controlled entirely from the floors beneath. Its disadvantage lies in the fact that it rotates the sun's image as the sun's hour angle changes—an effect, however, to which the observer easily becomes accustomed.

This equipment was provided from a fund generously given to the Whitin Observatory by Miss Elizabeth Phoebe Whiting in memory of her sister, Professor Sarah Frances Whiting* (1846-1927), first Director of the observatory. With the exception of the grating, which was made at the Mount Wilson Observatory, the spectrohelioscope was made by Howell & Sherburne of Pasadena. The image-forming lens was made by Lundin, the plane mirrors by the Alvan Clark & Sons Corporation, and the heliostat, dome, and system of controls by the Eastern Science Supply Company of Boston. All the mirrors have been coated with aluminum by Dr. R. C. Williams of Cornell University.

Observations with this spectrohelioscope may be supplemented by direct observations of the solar disk with the 6-inch and 12-inch reflectors, and by observations of prominences with an Evershed spectroscope attached to the smaller telescope.

*Not to be confused with the founder of the observatory, Mrs. John C. Whitin.

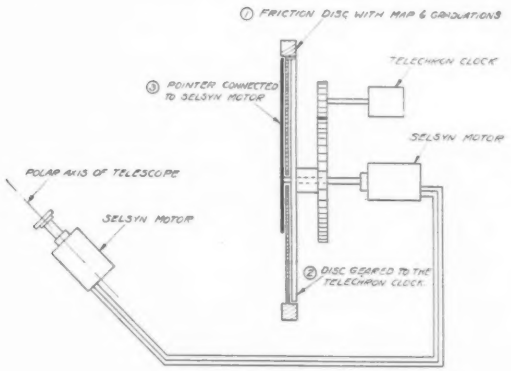
A New Star-Finder

By G. CAMILLI*

Ordinarily in order to direct an equatorial telescope to some object in the sky, it is necessary to know the right ascension and declination of the object, and the correct sidereal time at the moment of observation. Declination is computed in degrees and if the telescope is provided with circles, it is an easy matter to set the telescope to the declination of the object to be observed.

By knowing the right ascension of the object and the correct sidereal time at the moment of observation, it is possible to compute the hour angle which is used to set the polar axis of the telescope. A new star finder has been developed which very much simplifies the last operation. When this finder is used no knowledge of sidereal time is necessary.

The apparatus is self-contained and is independent from the telescope proper. It can be hung on the wall of the observatory. The apparatus is electrically connected to the polar axis of the telescope by means of two Selsyn motors. Selsyn motors are "self-synchronizing" and when two are connected to the same power source the shaft of one turns in exact step with that of the other as if they were mechanically coupled.


① FRICTION DISC WITH MAP & GRADUATIONS
TELECHRON CLOCK
③ POINTER CONNECTED TO SELSYN MOTOR
SELSYN MOTOR
POLAR AXIS OF TELESCOPE
SELSYN MOTOR
② DISC GEARED TO THE TELECHRON CLOCK

Referring to the accompanying diagram, one Selsyn motor is connected to the polar axis of the telescope while another Selsyn motor is connected to a pointer which moves across a star map which is placed on a disc (1). A telechron clock, geared approximately to sidereal time, carries a disc (2), which, as it turns, moves (by friction) the disc (1) and the star map. The operation of the device is as follows:

First, the telescope is pointed to a "known" star. If the telescope is

*General Electric Co., Pittsfield, Massachusetts.

provided with a driving mechanism it is made to follow that star. Second, the disc (1) is made to slide (by hand) over the disc (2) until the pointer (3) is reading the star to which the telescope is pointed. Since the telechron clock carries the star map (to sidereal time), to find any other object in the sky it is only necessary to turn the polar axis of the telescope until the pointer on the map corresponds to the desired object in the sky.

Of course this star finder does not take care of the declination axis which must be set in the conventional manner.

Planet Notes for May, 1936

By CLIFFORD E. SMITH

Note: All times, unless otherwise stated, are Central Standard Time.

The *Sun* will be moving with an apparent northeasterly motion from the central part of Aries to the central part of Taurus. Its distance from the earth will increase from about 93.6 to about 94.2 million miles. The position of the sun on the first and last days of the month will be, respectively: R.A. $2^h\ 32^m$, Decl. $+14°\ 57'$, and R.A. $4^h\ 31^m$, Decl. $+21°\ 52'$.

The phenomena of the *Moon* will occur as follows:

Full Moon	May	6 at	9 A.M.
Last Quarter		13 "	12 MIDNIGHT
New Moon		20 "	3 P.M.
First Quarter		27 "	9 P.M.
Apogee		3 "	6 A.M.
"		30 "	9 P.M.
Perigee		18 "	9 P.M.

Mercury will be an evening object in Taurus. Its apparent motion among the stars will be easterly until May 20 when it will become westerly. Early in the month it will set about an hour after the sun. Greatest elongation east will occur on May 7 at noon (21° 20′). Toward the middle of the month it will begin to approach the sun rapidly in apparent position. Inferior conjunction will occur at 6:00 A.M. on May 31. The distance from the earth to Mercury will decrease from about 90 to about 50 million miles, and the apparent diameter will increase from about 7 to about 12 seconds of arc. Conjunction with the moon will occur on May 21 at 2:00 P.M. (Mercury 1°3 S). The position of Mercury on the first day of the month will be R.A. $3^h\ 49^m$, Decl. $+22°\ 28'$. Its position on the fifteenth of the month will be R.A. $4^h\ 46^m$, Decl. $+24°\ 16'$.

Venus will be a morning object near the border of Pisces and Taurus. During the middle of the month it will rise about fifty minutes before the sun. Its distance from the earth will be about 155 million miles, and its apparent diameter will be about 10 seconds of arc. Its apparent motion among the stars will be direct (easterly). A conjunction with Uranus will occur on May 10 at 3:00 A.M. (Venus 51′ S), and a conjunction with the moon will occur on May 19 at 10:00 P.M. (Venus 4°8 S).

Mars will be too near the sun in apparent position to be of interest. Conjunction with the sun will occur in June.

Jupiter will be a night object in southern Ophiuchus. It will rise about 9:00 P.M., local standard time for northern observers. Its apparent motion among the stars will be retrograde (westerly). The distance from the earth to Jupiter will be about 410 million miles, and its apparent diameter will be about 42 seconds of arc. Conjunction with the moon will occur on May 9 at 10:00 A.M. (Jupiter 1°6 N).

Saturn will be a morning object in northern Aquarius. During the middle of the month it will rise about 2:00 A.M., local standard time. Its apparent motion among the stars will be direct. Its distance from the earth will be about 940 million miles, and the diameter of the planet proper will be about 15 seconds of arc. Conjunction with the moon will occur on May 16 at 4:00 A.M. (Saturn 7°6 S).

Uranus will be a morning object in western Aries, and rather near the sun in apparent position. During the middle of the month it will rise about an hour before the sun. Its distance from the earth will be about 1970 million miles, and its apparent diameter will be about 3.3 seconds of arc. Conjunction with Venus will occur on May 10 at 3:00 A.M. (Uranus 51′ N), and conjunction with the moon will occur on May 19 at 4:00 A.M. (Uranus 5°0 S). Its position on May 15 will be R.A. $2^h\ 18^m$, Decl. $+13°\ 17'$.

Neptune will continue as an evening object in southeastern Leo about a degree southeast of χ Leonis. During the middle of the month it will be on the meridian (toward the south) at about 7:30 P.M., local standard time. Its apparent motion among the stars will be westerly until May 25 when it will become easterly again. Conjunction with the moon will occur on May 1 at 10:00 A.M. and on May 28 at 4:00 P.M. (Neptune 6°5 N). The position of Neptune on May 15 will be R.A. $11^h\ 3^m$, Decl. $+7°\ 14'$.

VARIABLE STARS

Variable Star Notes from the American Association of Variable Star Observers

By LEON CAMPBELL, Recorder

Observers and Observations: In spite of the very inclement weather reported from all sections during the month of February, 3300 observations were secured by 73 observers, of whom three are new contributors: Paul A. Dahm, of Oshkosh, Wisconsin, working under the guidance of Ralph N. Buckstaff; John McNeill, of Evanston, Illinois, guided by William Callum; and Rev. Clifford H. Vessey, of Rowayton, Connecticut, guided by Lewis L. Doolittle.

Local A.A.V.S.O. Meeting at Harvard: Members of the A.A.V.S.O. and invited guests, totalling twenty-six, met at the Harvard Observatory, on March 4, for their first local meeting to talk over the program of proposed work and to plan for the Spring meeting of the Association which will be held at the American Museum of Natural History, in New York, on May 23. Brown University was represented by Professor Charles H. Smiley, Wellesley College by Professor J. C. Duncan, and Pine Manor Junior College by Miss Vera M. Gushee. First Vice-President Charles W. Elmer, of Southold, New York, was also present. Dr. Shapley presided. The meeting was informal and many points of interest were discussed. There was decribed in some detail the first contribution of variable star

observations, made by the A.A.V.S.O., that is to be published in *Harvard Annals*, Vol. 104. Proof reading of the material to be planographed revealed an average of seven clerical errors in one thousand observations between the original records and the material to be sent to the printer. Heretofore, only a partial check of the data sent to POPULAR ASTRONOMY had been made.

Suggestions were made for further improvement in the monthly reports on variable stars in POPULAR ASTRONOMY.

The matter of an A.A.V.S.O. exhibit at the time of the Tercentenary Celebration of Harvard University was also discussed. The Association certainly has much of interest to offer the professional and the layman on that occasion.

Progress on the work on the photovisual sequences for 40 to 50 variable stars to be added to the observing list was also described. Types of work which members might carry on in their homes or at Harvard Observatory were also outlined. This included general routine tasks of collecting published observations made in the early years by the A.A.V.S.O. and other observers, reduction to a uniform scale and the plotting of results for general discussion. Much effective work could also be done on Harvard plates on "unbekannt" stars listed in Prager's Catalogue for which little or no observational material now exists.

The meeting proved so successful that later meetings may be held at intervals throughout the year.

Recently Named Variable Stars: The Variable Star Commission of the Astronomische Gesellschaft has recently issued in *A.N.*, No. 6178-79, the designated names and numbers of 555 variables.

This Variable Star Commission is the official organ for assigning names and letters to variable stars, once such stars have been accepted as genuinely variable. The criteria laid down by the commission are rigid and there are many so-called variables to which names have not been assigned, awaiting further confirmation. If the original discoverers have sufficient material to ascertain the period or type of variation, or both, this is usually considered as conclusive evidence of variability.

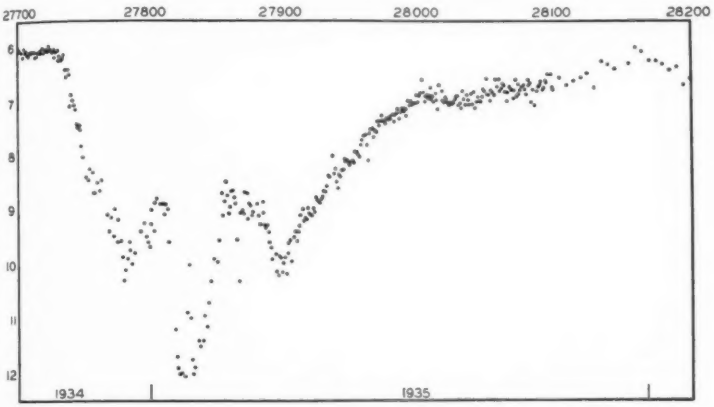
Four hundred of these variables were discovered on Harvard plates and were recently announced—without assigned names—in the Harvard publications. Of the total list, 284, more than half of these variables, are of the long period type; 100 of the RR Lyrae type; 97 of the Algol type; 16 of the Delta Cephei type. Three are listed as novae, including the recently well observed nova in Hercules, now to be known as DQ Herculis. The remaining 65 stars are divided into those of the W Ursae Majoris, R Coronae Borealis, RV Tauri, Beta Lyrae, U Geninorum, XX Ophiuchi, and cluster types. Periods have been found for most of these stars.

New Eclipsing Variables of Extremely Long Period: Two new eclipsing variables of extremely long period have been announced by Miss Henrietta H. Swope. One of these—known provisionally as H.V. 6990 (1740*35*)—has a period of 6475 days (17.7 years) and the other—H.V. 7021 (1746*38*)—a period of 4900 days (13.4 years). To date, only one other eclipsing star has a period longer than these, namely ϵ Aurigae, 9883 days (27 years). Incidentally, the Amateur Japanese Observers obtained a remarkably well observed light curve of ϵ Aurigae during the years 1928-30, when it passed through its latest minimum.

H.V. 6990 (1740*35*) varies from magnitude 12.3 to 16.0 and the duration of the eclipse is 670 days, slightly more than one-tenth of the total period. H.V. 7021 (1746*38*) varies between magnitudes 11.4 and 13.3 and the eclipse lasts about 590 days, approximately the same ratio to length of period as for H.V. 6990.

The eclipsing star which has the fourth longest period is ζ Aurigae, period 972 days. Epsilon and Zeta Aurigae are bright, visible to the unaided eye, and are only three degrees apart in the sky. The two long period eclipsing stars recently announced by Miss Swope are faint and separated by less than five degrees; they are seen as faint stars probably because they are situated in a region of the sky partially obscured by dark nebulosity.

Minimum of R Coronae Borealis: The 1934-35 observed minimum of R Coronae Borealis is shown in the figure, the points until J.D. 28100 being from single



1934-35 Minimum of R Coronae Borealis

day means and from there on, from five day means. This remarkable and erratic minimum occurred after the star had remained at a fairly constant maximum magnitude at 6.0 for ten years. The drop to tenth magnitude required about forty days and then there was a rise to magnitude 9.0. From here there was a renewed drop, even more sudden than the first decline. A well-marked secondary maximum at 10.0 occurred around J.D. 27830—late in January, 1935—dropping again within a few days to magnitude 12.0. Possibly a sudden decrease occurred about J.D. 27869. The secondary minimum about J.D. 27900 is well observed. From that date, the rise was progressive but with some fluctuations.

The variable seems to have reached maximum brightness again. How long it will remain there, how soon the next minimum will occur, and to what magnitude it will drop again, only time and assiduous observing can tell with certainty. It does not look as if any decided change in brightness will escape the attention of observers.

R Coronae Borealis, like others of its class, presents a real enigma. It appears never to do the same thing twice and appears to be even more erratic and irregular than the novae.

Not many variables have been found which can be classified as of the R Coronae Borealis type—certainly less than a dozen.

SU Tauri, S Apodis, and RY Sagittarii are three other well-known variables of this type now being observed by the A.A.V.S.O. Although other variables have been classified by some authorities as R Coronae Borealis stars the application of

suitable criteria shows that this designation is incorrect. A typical R Coronae Borealis variable should have a large range in magnitude—several magnitudes at least—remain at maximum, perhaps with fluctuations, for long intervals of time, and present marked irregularities in the light curve while at or near minimum. In general the characteristics are the antitheses of those found in many novae.

Two New Photographic Novae: The list of novae has been augmented by the discovery of two more of them, by Miss Swope, in the constellation of Scorpius on Harvard plates. To be sure, they made their appearances in 1893 and 1901, respectively. The first, H.V. 7104 (175439), reached twelfth magnitude, according to the plates, but may have been actually brighter in the interval between May 1 and 19, 1893, when it was recorded as of magnitude 12.6. The drop in twenty days from 12.6 to fainter than 15.0 is certainly rapid, but not entirely unprecedented.

The other nova, H.V. 7006 (174535), attained the magnitude 9.4 (photographic) and may have been more brilliant. Seventeen days before its appearance at magnitude 9.4, on September 3, 1901, the star was fainter than magnitude 16.5. Its decrease to minimum was evidently very rapid, according to the plates.

A.A.V.S.O. Nova Search and Photographic Committees: Mr. L. E. Armfield and Mr. L. H. Matthias, of Milwaukee, Wisconsin, both active in the A.A.V.S.O. and the A.A.A.A., have accepted the Chairmanships of the Nova Search and Photographic Committees, respectively. They will appoint others to serve with them. The Nova Search Committee will have charge of the program assigned for the prompt detection of bright novae, by visual methods, confining their work in the main, to naked-eye stars. A few observers will watch telescopic fields for detection of novae brighter than the ninth magnitude, although the search doubtless could be carried on more effectively by photographic methods. Regions numbering 175, approximately ten degrees square, have been delineated throughout the whole Milky Way and two or more of these regions will be assigned eventually to each volunteer observer. For further details, Mr. Armfield should be consulted.

The Photographic Committee is designed to inaugurate photographic investigation by amateurs who are, or soon may be, equipped to carry on systematic work in photographing the sky according to an accepted plan. Regular sky patrol work for the discovery of novae, asteroids, comets, and variable stars is suggested. Studies of the variables with larger telescopes, using special screens and plates to obtain results in the yellow and infra-red portions of the spectrum are also proposed. Here again, Mr. Matthias should be consulted for more complete details as to problems and methods of observation.

A Celestial "Window": A recent study of the variable stars found in one of the Harvard Milky Way regions reveals what seems to be unmistakable evidence of another celestial "window," one of those holes in the Milky Way which shows stars far beyond its center.

The average long period variable star included in the program of the A.A.V.S.O. is, at maximum, of absolute visual magnitude about —1.5. When such stars are only of the tenth apparent magnitude at maximum, we conclude that their distances are approximately 2000 parsecs, or 6500 light years. The brighter ones, on the average, are nearer, and the fainter ones are more remote, but of course there is a considerable spread in the values about the average and one cannot compute with accuracy the distance of an individual long period variable star from its observed maximum magnitude alone. However, for a group of such stars of about

the same magnitude in a limited field, the estimate of distance should be fairly reliable.

Some exceptionally faint long period variable stars have been found and studied by Dr. Shapley and Miss Swope through this new window in the southern constellations of Pavo and Ara, and the distribution of the distances of these seventy-nine new long period variable stars has been discussed. These variables are typical so far as length of period, color, and range of variation are concerned.

Their outstanding peculiarity lies in the fact that more than half of them do not become brighter than the thirteenth photographic magnitude at maximum. Sixteen are of the fourteenth magnitude and fainter. There are many Cepheid variables of this same magnitude included in the Milky Way field under investigation. If their light is not absorbed by interstellar material, some of them are more than 10,000 parsecs distant. They are, in fact, more remote from the earth than is the center of our galaxy.

From a study of long exposure photographs with the Bruce telescope in South Africa, it has been found that the distribution of external galaxies throughout this same region of Pavo leads to the conclusion that space absorption in this particular section is not very serious. Here the spiral nebulae are in abundance and they are intermingled on the surface of the sky with not only long period variable stars but also with variables of other types. If the absorption were considerable, the number of external galaxies would be diminished far below normal or perhaps cut off altogether, as is the case in so many parts of the Milky Way.

Dr. Shapley therefore concludes that in the direction of the constellations Pavo and Ara, the total space absorption cannot exceed a tenth of a magnitude per kiloparsec, and accordingly some of these faint long-period variables are beyond the galactic center, which is now considered to be about 35,000 light years away. It is through "windows" such as these in the absorbing material of the Milky Way that we can best measure the extent of our stellar system and study the stars that lie beyond its center.

March 17, 1936.

Nova Herculis 1934.—Professor Otto Struve, director of the Yerkes Observatory, sends the following statement:

"Professor Biesbroeck reports that from a visual observation of Nova Herculis on March 18, the two components have now a distance of 0".31, while their magnitudes still differ by 0.6 magnitude. There is no change in the position angle. The expansion mentioned in *Astrophysical Journal*, **82**, 433, 1935, is therefore progressing at a nearly uniform rate." HARLOW SHAPLEY.

Harvard College Observatory Announcement Card 369. March 23, 1936.

Comet Notes

By G. VAN BIESBROECK

Cometary observations are still confined to faint objects visible only with the larger telescopes.

When last examined here (March 18) by the writer, PERIODIC COMET 1927 III (COMAS SOLÁ) appeared as a diffuse coma with a fairly well defined nucleus, the nebulosity extending mostly toward the preceding side as a short tail. The total brightness was, however, fainter than that of a 14^M star.

Still fainter was PERIODIC COMET 1929 I (SCHWASSMANN-WACHMANN) on

that same night. It appeared as a round coma of total brightness 15.5 slightly condensed toward the center.

A first attempt at locating COMET 1935 *d* (VAN BIESBROECK) since its conjunction with the sun showed (Feb. 28) a diffuse object quite close to the position resulting from the ephemeris (p. 152). Unfavorable weather conditions have not given an opportunity to confirm this first information. The conditions of visibility are rapidly improving so that further observations will soon be forthcoming, but the object will evidently remain faint.

Williams Bay, Wisconsin, March 19, 1936.

METEORS AND METEORITES

Meteor Notes from the American Meteor Society

By CHARLES P. OLIVIER, President

The accompanying tables give the Society's Annual Report for 1935. Were the value of the year's work to be measured by the total number of meteors reported, it would seem that we had regressed sadly from the years 1932 and 1933. But such a conclusion would be most erroneous. In those years our totals were made greater by thousands of observations, largely counts, by totally untrained temporary observers working during the Perseid and Leonid epochs. In 1935 the full moon and much cloudy weather ruined the Perseid maximum; and the country had an unprecedented cloudy spell for the Leonids, as our records show. While we are happy to receive counts and other observations, no matter how inexperienced the observer, yet they are not so valuable as similar work from our trained observers, many of whom are working in splendidly organized groups. The work by some members and some groups was better in 1935 than ever before, and the results for the year are therefore most gratifying.

In America, where many deserve honorable mention, two groups did outstanding work: these were the Missouri-Illinois observers under J. Wesley Simpson and the Wisconsin-Northern-Illinois group under L. E. Armfield. In New Zealand, splendid reports were made by the small but active group under the leadership of R. A. McIntosh. The reports from these three groups make up far the larger part of the total. The interest in the Hoffmeister-Olivier program, designed to aid in the study of the daily and annual variation of meteor frequency, was well maintained, and the plan is being further followed in 1936. Special sheets were devised and distributed for this work. New supplies of maps, blanks, and bulletins for all purposes are also available.

Interest in telescopic meteors is steadily growing, and Table III shows several observers who made notable contributions. We are steadily collecting data which will permit a better attack to be made upon the problems connected with these little-known bodies. Several of our members are having some success in meteor photography, a field as yet hardly touched in most phases. During the past year we were able to find one excellent Leonid height from plates taken at two stations and sent in to us by Alfred Boyles of Ensley, Alabama. The final lists of heights from three Leonid displays were published, and much work done on their discussion. Several meteor problems are being actively attacked by the staff of Flower Observatory, many of the data coming from the A.M.S. As usual, we are much indebted to the U. S. Weather Bureau and to the Hydrographic Office, U.S.N., for

observations of fireballs. The coöperation of the press has been excellent, and through it valuable results have been attained, both at times of showers and after the appearance of brilliant fireballs. A new observing group is being organized in Arkansas, and inactive groups in other parts of the country are being revived. We are fortunate in now having several observers in Japan, and Honolulu observers are still reporting to us.

The writer desires to express his appreciation for this work and coöperation to all members who have sent in observations, but most especially to the regional directors, who have put in so much time and effort and to whom the success of the year's work is so largely due. A word of thanks is also hereby given to members of the A.A.V.S.O. for telescopic meteor observations and to other amateurs who have kindly sent in reports of meteors. We trust that 1936, being more favorable than last year as to moonlight at shower epochs, will see an even better showing than did 1935.

The work of the A.M.S. was aided in 1935 by a grant of $150 from the Research Fund of the University of Pennsylvania, and a study of meteor train phenomena is being financed by a grant of $1000 from the American Philosophical Society. We are under deep obligation for these most important financial assistances. As our headquarters are at Flower Observatory, and its resources and much of the time of its staff are used for the benefit of the American Meteor Society, it is obvious that the University of Pennsylvania largely supports our activities. Without this cordial support, it would be impossible to continue the work of the Society on anything like its present scale or efficiency.

TABLE I[8]

Name and Station	Nights	Meteors
Albrecht, Wm. B., Milwaukee, Wisconsin	8	42[1]
Alpha Nu Fraternity, Beta Chapter, Denver, Colorado	8	133[1]
Black, James L., Cleveland, Ohio	14	150
Buddhue, John D., Pasadena, California	1	40
Cook, Allan F., II, Westfield, New Jersey	3	65
Diedrich, George, Milwaukee, Wisconsin	16	125[1]
Fairbrother, S. R., Tadmor, Nelson, New Zealand	27	701
Friton, E. E., St. Louis, Missouri	18	279
Geddes, M., Otekura, New Zealand	16	521
Graham, Julian W., Salem, Oregon	27	157
Halbach, Edward, Milwaukee, Wisconsin	4	44[1]
Inouye, Hideo, Nagoya, Japan	14+	198
Jewett, Mary L., Grandview, Tennessee	2	44
Kent, J. Thurston, Jackson, Tennessee	4	96
Khan, Mohd. A. R., Begumpet, Deccan, N.S.R., India	16	219[3]
Lamb, J. E., Regina, Saskatchewan, Canada	10	97
Larrabee, Louise M., Honolulu, T. H.	5	46[3]
Loreta, Eppe, Bologna, Italy	—	338
Martz, Ed. Jr., Oak Park, Illinois	11	184[1]
McIntosh, R. A., Auckland, New Zealand	15	515
Mittendorf, Ed., Lake Geneva, Wisconsin	5	62[1]
Parker, P. O., Cohutta, Georgia	3	48
Paterson, J. Fraser, Broken Hill, Australia	10	68[3]
Pearce, R. Stanley, Kellogg, Idaho	3	140
Peck, Arthur S., Milwaukee, Wisconsin	9	138[4]
Preucil, Frank, Joliet, Illinois	2	72
Pruett, Mrs. J. Hugh, Eugene, Oregon	2	76
Pruett, J. Hugh, Eugene, Oregon	3	127
Reed, R. Gardner, Fall River, Massachusetts	1	57
Simpson, J. Wesley, Webster Groves, Missouri	20	681[3]
Skinner, Gerald B., Brockton, Massachusetts	3	99
Smith, Franklin W., Glenolden, Pennsylvania	36	416

Tomkins, T. K., North Hills, Pennsylvania	6	65
Wheeler, Clarence J., Jr., Dallas, Texas	8	323[3]
12 members reporting less than 40 each	21	214
Previously unreported 1934 observations:		
Alpha Nu Fraternity, Beta Chapter	5	203[4]
Geddes, M.	7	266
		7,049

[1] Timed counts, Hoffmeister-Olivier program.
[2] At least half counted, not plotted.
[3] On 7 of these nights, observations with assistance of Charles H. Connolly.
[4] Hoffmeister-Olivier program, but 56 meteors plotted.
[5] Observations from members are listed in this table. In general, the meteor paths were plotted.

TABLE II[3]

Name and Station	Nights	Meteors
Eleven of Miss Larrabee's students, Honolulu, T. H.	4	495
Missouri-Southern Illinois Observers:		
Brady, James, Webster Groves, Missouri	7	257[1]
Brockmeyer, Chas., Webster Groves, Missouri, and Fredonia, Kentucky	20	474[1]
Ellison, Miss M. L., Webster Groves, Missouri	25	429[1]
Felker, Jean, Kirkwood, Mo., and Webster Groves	13	255[1]
Lindsay, P. M., Los Angeles, California	19	815[2]
Nelson, E.	12	504[2]
Winn, H., Los Angeles, California	18	637[2]
41 others reporting less than 100 meteors each		1,228[1,2]
Wisconsin Observers:		
Abrahams, Richard, Milwaukee, Wisconsin	38	316[1]
Boehm, Joseph E., Lake Geneva, Wisconsin	11	178[1]
Keuziah, Mike, Milwaukee, Wisconsin	30	542[1]
Legel, Edward, West Allis, Wisconsin	11	178[1]
Luczka, John, Milwaukee, Wisconsin	8	134[1]
30 others reporting less than 100 meteors each		1,012[1]
Seven non-members reporting less than 100 meteors each		166
		7,620

[1] Timed counts, Hoffmeister-Olivier program.
[2] Plotted.
[3] Observations from non-members are listed in this table. In general, the meteor paths were not plotted.

TABLE III

TELESCOPIC METEORS

Armfield, L. E., Milwaukee, Wisconsin	58
Brockmeyer, Chas., Fredonia, Kentucky	2
Callum, Wm., Chicago, Illinois	5
Cook, Allan F. II, Westfield, New Jersey	4
Flower Observatory, Upper Darby, Pennsylvania	31
Fritton, E. E., St. Louis, Missouri	9
Halbach, Edward, Milwaukee, Wisconsin	10
Jones, E. H., Goffstown, New Hampshire	22
Kirkpatrick, George, Piermont, New York	2
Knabe, Robert, Tucson, Arizona	202
Lindsay, P. M., Los Angeles, California	1
Loreta, Eppe, Bologna, Italy	2
Preucil, Frank, Joliet, Illinois	44
Rosebrugh, D. W., Poughkeepsie, New York	1
Simpson, J. Wesley, Webster Groves, Missouri	13
Smith, Franklin W., Glenolden, Pennsylvania	9
Williams, J. D., Tucson, Arizona	20

For 1932, previously unreported:	
Geddes, M., Otekura, New Zealand	12
Morshead, F. J., New Plymouth, New Zealand	3
Wilkinson, D., New Plymouth, New Zealand	1
For 1933, previously unreported:	
Bateson, F. M., Wellington, New Zealand	6
Bryce, Allan, Hamilton, New Zealand	2
Smith, G. S., Opoho, Dunedin, New Zealand	3
For 1934, previously unreported:	
Bryce, Allan, Hamilton, New Zealand	2
Geddes, M., Otekura and New Plymouth, New Zealand	5
Smith, G. S., Opoho, Dunedin, New Zealand	8
Whitney, B. S., Norman, Oklahoma	2
	479

Table I	7,049
Table II	7,620
Table III	479
Photographic Meteors	8
Perseid Epoch	737
Additional 1934 Perseids	187
Restricted showers, non-members	160
Fireballs	254
Grand Total for 1935	16,494

Flower Observatory of the University of Pennsylvania,
Upper Darby, Pennsylvania, 1936 March 17.

Contributions from the Society for Research on Meteorites

Edited by FREDERICK C. LEONARD, President, *and* H. H. NININGER, Secretary

"Preliminary Results of the Meteorite Expeditions Made in the Decade 1921-31," By L. Kulik[1]

Translated by LINCOLN LA PAZ *and* GERHARD WIENS,
Of the Ohio State University and the University of Idaho

In view of the fact that in the past decade a number of scientists [have] altogether denied the very occurrence of the fall of the meteorite of 1908 June 30, my first reconnoitering trips through Siberia and to the Podkamennaya Tunguska River in 1921-27 and in 1928 were devoted mainly to the collection, from eye-witnesses, of data concerning the circumstances of the fall. In the process, I discovered woods, blown down along radial lines (Figs. 1 and 2),[2] and I hastily

[1] Published originally in the *Works of the Lomonossoff Institute of the Russian Academy of Sciences*, Part 2 (1933), pp. 73-80. As a result of the re-organization of the Mineralogical Museum of the Russian Academy of Sciences, at first into the Institute of Mineralogy, and then into the Lomonossoff Institute of Geochemistry, Crystallography, and Mineralogy, the *Works* of the Museum and of the Institute no longer appear as independent series under these titles, but are continued in the series on Crystallography and Mineralogy comprised in the *Works of the Lomonossoff Institute*.

Translated from the Russian of L. Kulik by Gerhard Wiens, Department of Modern Languages, University of Idaho, at the suggestion and with the coöperation of Lincoln La Paz, Department of Mathematics, Ohio State University. Words inclosed in square brackets [] have been inserted by the translators.

[2] [It has been possible to reproduce only Fig. 1 and Fig. 3 in this translation.]

examined the central portion, about 5×5 square kilometers in area, of this broken-down timber. In 1929-30, I conducted another expedition, during which I wintered at the place of the fall, my aim being to clear up a number of questions and to study the locality systematically.

The testimony of witnesses, the optical phenomena, the mighty seismic vibrations and air-waves, the complete prostration of trees along radial lines over an area with a diameter of more than sixty kilometers, and the continuous, uniform charring of the blown-down woods in the central area, out to a radial distance of fifteen kilometers, as well as the magnificent [phenomena occasioned by the] pulverization of the material of the meteorite in the atmosphere (nocturnal atmospheric glows, white nights)[3]—all these things had long [ago] brought me to the

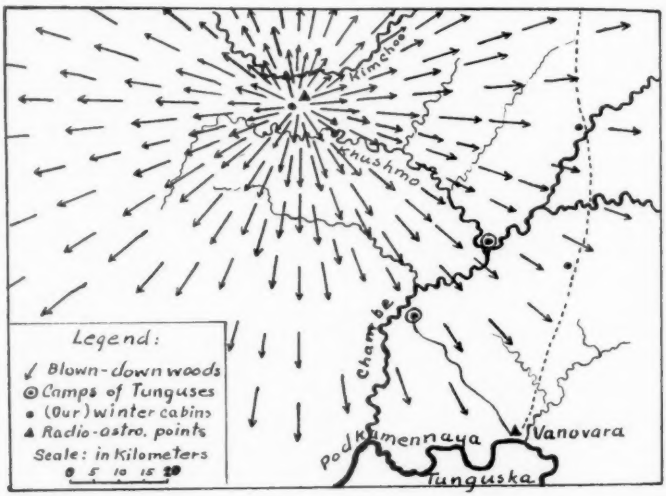


FIGURE 1
PLAN OF THE BLOWN-DOWN WOODS

firm conviction that the meteorite fall of 1908 June 30 quite transcended the ordinary falls of meteorites, retarded [as these are] by the air. Moreover, I believed that in this fall, as a consequence of the transformation of the colossal kinetic energy of this morning meteorite, there had occurred, at the instant of its impact with the earth, an explosion which resulted in the formation of craters in the ground. This is the reason why, in the center of the blown-down woods, our attention was attracted first of all by the circular depressions that looked like meteorite craters. There were many such depressions. In Leningrad it was objected that these depressions are normal formations connected with the southern boundary of perpetually frozen ground [sub-soil]. It was pointed out to us that

[3] [Consult in this connection: F. J. W. Whipple, "The Great Siberian Meteor and the Waves, Seismic and Aërial, which it Produced," *Quar. Jour. Roy. Meteorol. Soc.*, **56** (1930), pp. 287-304; I. S. Astapowitsch, "Air Waves Caused by the Fall of the Meteorite on 30th June, 1908, in Central Siberia," *ibid.*, **60** (1934), pp. 493-504; and F. J. W. Whipple, "On Phenomena Related to the Great Siberian Meteor," *ibid.*, **60** (1934), pp. 505-13.]

in the region beyond Lake Baikal, the incomplete junction of the winter ice and the perpetual ice brings about the presence of isolated, water-filled cavities in the soil, between the two frozen horizons, and that during further congelation [of the water in these cavities], small mounds are formed which burst under the expansion of the encased water and thereby give rise to crater-like holes. Others based their objections on the karst phenomena in the limestone, which they supposed to exist in the central region of the fall; or, they suspected the presence in that region of lenses of salt which, as a result of very complicated processes, might, in their opinion, have produced the semblance of nearly round meteorite craters.

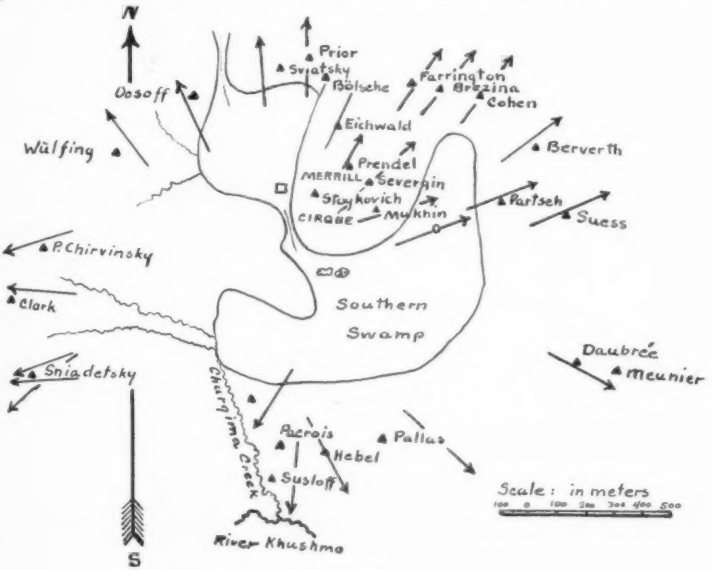


FIGURE 3

SCHEMATIC DRAWING OF THE CENTRAL AREA OF THE BLOWN-DOWN WOODS

It shows: (*a*), by arrows, the direction of the blown-down trees, determined by means of a compass; (*b*), by triangles, the summits of hills, determined by means of a theodolite; (*c*), by the square, the place of investigations conducted in 1929-30. In 1929, the geodesist S. Y. Byelykh established on the hill "Farrington" an astronomical point whose coördinates are:

$$\phi = +60^\circ\ 54'\ 58''.98; \qquad \lambda = 101^\circ\ 56'\ 59''.79\ E.$$

In 1929-30 we were twenty months on our expedition, and spent the winter in the center of the blown-down woods. The region is hilly territory composed for the most part of Siberian trap-rocks which, in the valleys, are covered with diluvial deposits. This region is the watershed between two small rivers, the Khushmo and the Kimchoo. In the northern section of this territory rough turf-marshes prevail amidst the hills (Fig. 3), while in the southern section there is a swamp. The whole central region of the blown-down woods, to judge by the remaining dead trees, has been scorched from *above;* the soil, likewise, shows traces of scorching, but there are indications also of new growth.

The probable center of the fall and of the anticipated discovery of meteorite craters, is, in our opinion, the southern swamp (Fig. 4[2]); to all appearances, this swamp owes its present condition solely to the fall of the meteorite. Since circumstances did not permit us to work in this southern swamp, we began our systematic investigations in the northern section of the central area of the blown-down woods, the section accessible for boring (Figs. 3 and 5[3]).

Work on the rough turf-marshes in 1929-30 revealed that here, as well as in the southern swamp, there are indications of a formerly higher water level; likewise, there were revealed unquestionable traces of the shifting and washing away of turf masses, of their displacement, of the gathering up of the turf and the clays into folds (Fig. 6[2]), and, in places, of the intermixture of the turf with the upper layers of clays below it (Fig. 7[2]). A preliminary familiarization with the geological character of the central area of the blown-down woods showed an almost universal distribution of trap-rocks below the sedimentary strata, and the absence, in the area investigated, of limestone, gypsum, and lenses or layers of salt. Three bore-holes (Figs. 8[2], 9[2], and 10[4]), which we made on the edge and in the center of one of the circular depressions in the rough turf-marshes (the greatest depth attained in one of the bore-holes being 31.5 meters), showed the presence, under the layer of surface turf (0 to 2 meters thick), of perpetually frozen, heterogeneous clay deposits to the depth of 25 meters, and below them—a water-carrying horizon in sand deposits. We did not cut through the water-carrying horizon for lack of boring pipes.

The temperature of the perpetual ice under the depression proved to be higher than in the surrounding territory. The surface of the swamp in this depression is luxuriantly overgrown with sphagnum [bog-moss], whose age does not exceed twenty years. The surrounding young arboreal growth is of the same age.

The winter ice and the perpetual ice joined completely about the beginning of the new year, the covering of snow being more than one-half meter thick, and the minimum temperature of the winter of 1929-30 being —56° C.

The southern boundary of uninterrupted, perpetually frozen ground lies, for the meridian of the center of the blown-down woods, in any case considerably south of the River Angara, *i.e.* many hundreds of kilometers to the south of the center of the fall.

Since the whole central region of the blown-down woods is now covered by a solid layer of moss (except in a few rocky places in the hills), the search for individual fragments of the meteorite on the surface is made very difficult at the present time, although the natives report that they formerly used to find pieces of "pure" iron in the vicinity of the center of the blown-down woods.

Our investigations, as yet unfinished (especially as regards the boring), have not yielded an exhaustive answer to the question concerning the origin of the circular depressions (occasionally referred to as craters in the literature about the Tungus meteorite) in the northern half of the central area of the blown-down woods. Neither the karst nor the salt theory, nor the theory of [water] bubbles between the incompletely joining winter ice and perpetual ice [horizons] can give us an explanation of the origin of these formations.

Besides the meteorite theory proper, concerning the origin of certain circular depressions on the rough turf-marshes in the center of the blown-down woods, we can, at present, offer a series of other hypotheses; we shall mention only the following:

[4] [Fig. 10 was omitted in the original paper.]

First, these depressions may be connected with the folds we discovered in the turf-marshes, which were formed probably by the pressure of the air waves occasioned by the explosive penetration of fragments of the meteorite into the soil. On the other hand, these depressions may be connected also with the partial breaking up of the continuity of the turf covering, and with the latter's floating to the surface, and being carried away in consequence of the inundation caused by the fact that the real meteorite craters [which] we believe to exist in the southern section of the center of the blown-down woods, served as artesian wells, after individual pieces (of a minimum weight of several hundred tons) of the meteorite struck through the [stratum of] perpetual ice and reached the water-carrying horizon.[8] The indubitable traces of an inundation are in agreement likewise with the testimony of witnesses, who relate that, at the moment of the fall of the meteorite of 1908, the ground was struck through, and that for several days afterwards water shot up out of the earth. There is the further (and apparently more probable) possibility [that the depressions are due to] the combined action of the inundation and of the dislocations in the turf under sharply changed conditions of insolation, ascribable to the general burning and practically instantaneous destruction of the woods over a huge area. Finally, it is conceivable also that the warming up of the perpetual ice and the formation of these circular depressions began under the influence of small, second-rate fragments of the meteorite (perhaps a few dozen tons in weight) which were retarded by the air, and, like the Goba [Hoba] (South-West Africa) meteorite, did not strike through the ground to form deep craters, but penetrated only through the turf to the perpetual ice which here, in the summer, lies at the average depth of only 0.5 meter. By virtue of their own great conductivity of heat and their destruction of the continuity of the non-conducting covering, these meteorite fragments could, under the catastrophically changed conditions of insolation, have promoted the warming up of the perpetual ice and the formation of small circular depressions.

In the midst of the rough turf-marshes in the center of the fall, from one of the present swampy watercourses which we might assume to have been one of the channels followed by the previously mentioned artesian waters, we took a sample of the clay, which showed the finest, sharp-angled, still unweathered material—the result of an explosive breaking up of local trap-rocks into minute fragments.

To summarize, we have, at this time, first: a great number of indications of the fall of a colossal meteorite, observed by our contemporaries, which struck the surface of the earth with an explosion; and, second, our unfinished investigations of the place of this fall, which apparently was of at least the same order of magnitude as the Australian, Arabian, and other falls, of which the craters were discovered in 1931, [but] concerning which it is so far unknown whether the actual falls were observed by anyone.

The problems next in order in the investigation of the place of the Tungus

[8] [The preceding is a *literal* translation. The meaning of this sentence may be clarified somewhat by the following paraphrase, supplied by the senior translator:

"On the other hand, these depressions may be connected also with the partial breaking up of the continuity of the turf covering and with the latter's floating to the surface and being carried away as the result of a flood. To account for such an inundation, we may suppose that the real meteorite craters (which we believe to exist in the southern section of the center of the blown-down woods) served as artesian wells. Such wells might develop after the individual pieces of the meteorite (of a minimum weight of several hundred tons) struck through the stratum of perpetual ice and reached the water-carrying horizon."—EDITOR.]

fall of 1908 are: (1) Air-photography, for the purpose of obtaining an exact picture of the blown-down woods and of the geometrical center of the points of departure of the air waves which broke down the trees, and (2) leveling[6] of the bottom of the southern swamp, in order to disclose the meteorite craters [which] we believe to be there.

In the years 1931-33, the Academy of Sciences of the U.S.S.R. has conducted no investigations at the place of the fall of the Tungus meteorite of 1908.

Secretary's Office: Nininger Laboratory, 1955 Fairfax Street, Denver, Colorado.
Editorial Office: Department of Astronomy, University of California at Los Angeles.

[6] [This term is used in the surveying sense; *i.e.* to indicate the process of running lines of levels, to give the relative elevations of points on the bottom of the southern swamp.]

A Brilliant Fireball

On the morning of March 14, 1936, the writer had just gone to bed after an evening of astronomical observations, when suddenly a rapidly brightening bluish glare lit up the window and room. One jump brought him to the window in time to watch a huge meteor flash by. The time was 2:47 E.S.T. (7:43 U.T.). The meteor was brilliantly blue, and about magnitude —15. There were two short yellow flares of about the 1st magnitude after the main part had died. The duration was estimated at 5 seconds, but this is not strictly accurate since my position was poor. About a minute or two after passage, a loud rumbling noise was heard, which persisted for close to one minute. This was certainly not the noise of a train or any other common disturbance, and might very well have been made by the meteor.

It was somewhat cloudy, and the moon was out (looking dull by comparison) hence it was not easy to plot the meteor's path. As observed by me, it seemed to travel southeast, between the following two positions:

From R.A. $12^h\ 40^m$, Decl. —2° to R.A. $14^h\ 36^m$, Decl. —15° (1920).

My position is approximately 40° 49′ 47″ north, and 74° 6′ 3″ west.

240 Washington Avenue, Rutherford, New Jersey. IRVING L. MEYER.

Communications and Comments

Under this heading we shall publish from time to time such material as does not properly fall under any of the established headings of this journal. Here, too, may be found, when occasion arises, articles which the editors may not be willing to give sanction to but which, nevertheless, may be provocative of thought along new lines.

Tidal Waves and Ocean Currents

By EDWARD GODFREY.

In recent years, astronomical observers have been noting facts about minute changes in apparent positions of stars that indicate clearly that the body of the earth heaves with the (apparent) passage of the moon across the sky.

These minute shifts of the stars have been found to bear a direct relation to the position (the hour angle) of the moon. In my judgment this can mean only one thing, and that is that the solid body of the earth is drawn out of shape,

elongated in the direction of the radius vector of the moon. It can be readily seen that if the body of the earth is so distorted, the meridian circle of any telescope set to observe the transit of stars will be in the true meridian plane only four times in 25 hours, and at all other times the star transits will appear to be a minute fraction of a second early or late.

This continual distortion of the shape of the earth is just what would be looked for from consideration of the forces exerted by the moon on the earth, combined with the centrifugal forces due to eccentric revolution of the earth, forced by the course of the moon in its orbit, as I have shown in a communication in POPULAR ASTRONOMY, August-September, 1934.

My theory concerning the action of gravitation and centrifugal force is quite different from any I have found in works on this subject. G. H. Darwin, for example, in his book "The Tides," says: "Every particle of the idealized non-rotating earth is continuously subject to equal and parallel centrifugal forces, in consequence of the revolution of the earth's center in its monthly orbit with a radius of 3,000 miles." This is quite in error, and Professor Darwin states that he got this idea of dealing with tides from Professor Davis of Harvard University. The very fact that the earth revolves once in a month about an axis 3000 miles from its center means, of necessity, that the centrifugal forces of the several particles of the earth are directly away from this axis, which is as far from being as stated by Professor Darwin as anything could be. Some of these forces are in fact toward the moon and not away from it. The total resultant for the whole body of the earth is a force applied at the earth's center directly away from the moon and equal to the moon's gravitational force on the earth.

The shift of stars is not explained by stretching of the earth's surface, as has been stated lately, but the whole body of the earth is elongated in the direction of the radius vector of the moon; so that sectional planes of the earth parallel to the equator are no longer circular but elliptical. Naturally the base of the meridian telescope, being normal to the elliptical curve, will follow that distorting curve, and this will throw the meridian circle to one side or the other of the axis or center of the earth.

The present communication deals more in particular with the nature of the tidal wave and its effect on the oceans. It is manifest to anyone who will give the matter complete study that the common theory of tides that tells us that the moon raises the water of the oceans beneath it by its gravitational force is quite untenable. High tide is never under the moon, and a retard of a period of time more than half that to the next high tide time is unthinkable. The so-called dynamic theory of the tide is equally out of accord with fact. The water of the ocean could not possibly travel with the velocity of the tide, if subject only to the minute differential force of the moon's gravitation. The sole force that the standard tidal theory can cite to actuate the ocean tide is a fleeting upward force that reaches its maximum when the moon is directly overhead, and that maximum is *one pound on 4000 tons of the water of the ocean.* But the crowning absurdity is that the water does not rise until about eight hours after that force has reached its maximum and hours after it has completely vanished and is replaced by reverse forces. On the other hand the differential force on the body of the earth, though minute on any particle, is gigantic when taken as a whole, and while it distorts the shape of the earth only a few score feet, the reaction on the earth is almost instantaneous, and the land wave travels as fast around the earth as the moon (apparently) travels.

The elongating force on a section through the center of the earth normal to

the radius vector of the moon is but a few pounds per square inch, but even this force exerted on rock or steel several thousand miles in length will account for elongation of several score feet in the direction of that radius vector; and since the force is instantaneous and applied just where the elongation is expected, there is no reason to look for any lag in the distortion of the body of the earth. The only lag is in the ocean wave itself, which, of course, could not respond instantaneously to the advancing earth wave. It is this land wave that forces the ocean wave we call the tide around the earth, the ocean wave lagging behind the trough of the land wave by but an hour or two. Every feature of tidal action agrees with this explanation. I believe that this theory of tidal action is new and original with myself. I do know that I have not read any hint of it in any book or heard a suggestion of it by anyone.

It is true that men have considered *and discarded* the idea of a land wave in investigating tides, but the conclusion has been that, since the water wave is so much higher than the land wave, the latter is insignificant, and hence consideration of it can be disregarded. This presupposes the condition that land wave and water wave are in the same phase, that is, that high land level and high water level must occur at the same time in any particular place. I find no other suggestion in any other investigation of land tides as compared with ocean tides in works of other writers. My theory, however, is that high tide is really an indication of low land elevation, and *vice versa*.

In investigating tides, men have detected a heaving of the earth, *and they have attributed this to the weight of the water on the land as the tide flows in*. This is mistaking cause for effect. The low land levels on the lateral sides of the earth, as viewed from the moon, force two tidal waves around the earth with a velocity that no ocean wave travelling in any "harmonic" sense, however great the wave, could possibly travel. The tidal wave is forced every mile of its travel by the advancing distorted shape of the body of the earth.

So-called tidal waves, or the seiches in small seas and lakes, find complete explanation in this same distortion of the earth's surface, including the phenomena of occasional exceptionally high tides, or waves. The effect of the distorting action of the moon on the body of the earth is to produce a rocking of the surface of the earth. It is as if one would take a pan of water and rock it. The inertia of the water would cause it to tend to remain level, but if one were small enough to walk on the edge of the pan, one would think that the water were rising or falling in a manner similar to the ebb and flow of the tide. When the bed of the lake is tilted or rocked, the water will be set in motion to some extent by friction on the bottom. If the next tilt has the same phase, the motion will be augmented. In this way, an occasional high tide will be observed in the lake because of synchronous action. Many analogous phenomena could be cited.

The very fact that these seiches occur in land-locked lakes and in bays that have narrow outlets to the ocean is proof that this phase of tidal action is not due to flow of ocean water or to an ocean wave traversing the earth, for in the lakes there is no connection with the ocean, and in the bays the narrow outlets are too small to admit enough water to account for the commotion.

Many writers treat the tidal waves as analogous to a wave that may be started by dropping a pebble in a still body of water. This is far from being the case. These writers aver that nothing travels in the wave except the form; the water, they say, merely rises and falls as the wave moves on. All of this is true of the waves in a still body of water which travel out in widening circles. The mean level of the water remains the same, and each crest of a wave borrows from the

water beneath the neighboring trough. The water thus travels a very short distance back and forth and to some extent up and down.

The case of the tides is in no sense analogous, and I believe that no other writer has pointed this out. The tide, instead of being a wave in the ordinary sense of the word, borrowing from beneath a neighboring crest and moving forward as a mere form, is in effect a vast body of water moving with tremendous momentum in a western direction across great oceans. In other words, the tide is equivalent to a flow of billions of tons of water against the eastern shores of the great continents.

The "trough" of the so-called tide wave is many thousands of miles away from the crest. It could not possibly borrow and return water in the manner of the circling waves of a pool. It is manifest that if the level of the water surface on a meridian, or the actual depth of the water at any time is greater, there is more water on that meridian at that time. If water were easily compressed or expanded, as a gas, a wave could be conceived as formed by gravitational force of the moon. But water is very slightly compressible and then only under heavy pressure.

A tide one foot deep on a meridian, covering one-quarter of the area of the earth, and tapering to zero depth, would mean something like 20,000,000,000,000 tons of water. Even a fraction of this, moving with a velocity of 1,000 miles per hour, would mean a tremendous and dynamic flow of water.

In the case of the Atlantic Ocean, for example, how does this surplus water that is forced against the western border of that ocean get back to the eastern border again? If the continental shore of North America were meridianal in its contour, doubtless the water would, at least in large measure, surge back, as it does in inland lakes, between high tide periods. But the shores of North America have a great sweep to the west, and a mass of water superimposed on the general ocean level, advancing on a north and south line, will have a great southern urge down the eastern shore of the continent. This flow can be seen in the Labrador current and in a less degree in the cold stream that hugs the shore of the states where it is masked by the so-called Gulf Stream. The latter has its motive force where the on-rushing tide wave is deflected by the shore of the northern part of South America and turns northward and through the Gulf of Mexico.

A study of ocean currents, having in mind the tide wave as a motive force, should convince anyone that the ocean currents are caused, not by prevailing winds, such as trade winds, as commonly explained, but by the onrushing superimposed wave of the tide in its continual western sweep across the great oceans. The backwash, as the currents turn and cross the oceans from west to east, only emphasizes the obvious fact that the water of the eastern regions of the oceans, pushed ever in a western direction by the earth wave, must return to the eastern regions again.

Scientists, I believe, have failed to offer any explanation for the fact that spring tides, neap tides, perigean and apogean tides lag back of the conditions that furnish their cause by a day or so. It seems to me that when the tide is viewed as virtually a current or flow of water superimposed on the mean ocean level (by virtually is meant that the effect is that of a flow, though the actual water in motion is not the same at all times) these delays have their explanation. When the tidal flow is higher and higher day by day, the eastern flow by way of ocean currents is not sufficient to balance the ocean level, hence a somewhat smaller urge may cause a higher tide than the previous day. Conversely, when the tidal urge (land wave) is less and less, eastern currents gain on the tidal supply of water. In other words ocean currents adjust themselves to the average flow of tidal water in any period, and short-time changes do not show immediate response.

Notes from Amateurs

Chicago Amateur Astronomical Association

The monthly meeting of the Chicago Astronomical Association was held in the Adler Planetarium and Astronomical Museum, Chicago, on Sunday afternoon, March 1. Mr. A. Herz, Chief Testing Engineer of the Public Service Company of Northern Illinois, was the speaker. Mr. Herz described the apparatus and preparations made for photographing the 1932 solar eclipse. His judgment in choosing Kennebunk, Maine, as his location was sound and he was rewarded with clear sky during the eclipse while at many other stations the sun was obscured by clouds. The movies of the eclipse were very beautiful and watching the moon slowly cover the disc of the sun and then the corona flash out was almost as good as seeing the eclipse itself. A number of still pictures were also shown. The whole program was most enjoyable and an inspiration to all our members.

There was a meeting of the west side section at the home of Ed. Martz, 726 N. Elmwood Avenue, Oak Park, on the evening of February 28. The night was cloudy but a number of interesting topics were discussed.

The south side meeting was held at 1319 W. 78th Street on Friday evening, March 13. The sky was clear for some time and we got a chance to see some of the nebulae and clusters. One or two variables were observed before the clouds drifted over again. George Warner led the first of a series of discussions on Optics and answered a number of questions on that subject.

WM. CALLUM, *Secretary.*

1319 W. 78th Street, Chicago, Illinois.

The Cleveland Astronomical Society

Our March meeting in the lecture room of the Warner and Swasey Observatory was well attended. All seats were taken and even standing room was at a premium. Dr. J. J. Nassau chose as his subject "Variable Stars." Many new lantern slides were shown as the lecture progressed through the different types of variables.

The members were given an opportunity to examine star fields on plates made at the observatory. Probably the most interesting part of the meeting was the explanation of the method used to estimate the distance of an object by the Cepheid variables associated with it. The sky cleared somewhat in the later evening allowing the use of the large refractor in the dome. At the end of the meeting a new movie film was shown picturing the process of grinding a mirror. It was a very good picture especially the section showing the stroke used and amount of overhang employed. This seems to puzzle many beginners but is quickly understood when presented on the screen.

Plans were discussed for the forthcoming dinner meeting of the society. A committee was appointed to decide on date and place. Members should not miss this meeting as a record attendance is expected. Some well-known speaker will be secured, name and subject to be announced later. If you are not now a member, submit your name at once so you will not miss this event.

DON H. JOHNSTON.

14 Lincoln Drive, Cleveland, Ohio.

Asteroid Notes

By HUGH S. RICE

Amateur astronomers who observe celestial objects with their telescopes may be classified into two types: asteroid hunters, and those who are not asteroid hunters. There are at least a few (we have no idea how many) who belong to the former category, ranking first among whom is a friend of this department, Morgan Sanders of Baltimore. From September, 1934, to February, 1936, he made 435 observations on 8 asteroids, with a small telescope. This means many hours of patient nocturnal work, and leads the telescopist to acquiring rare skill in this kind of work, and also to becoming familiar with the star fields involved. It would not be surprising if with such perseverance Mr. Sanders should sometime discover a nova or a comet, as has been done many times by variable-star observers. Such an occurrence would indeed be welcome to the general field of astronomy, inasmuch as we have had such a dearth of comets that are easily observable, lately, as can be learned from reading "Comet Notes" by Professor Van Biesbroeck in this periodical.

Mr. Sanders followed Juno from August, 1935, to January, 1936, the first locating of the planet being by means of an ephemeris, but this method was found to be more difficult than locating by the chart which appeared later. The chart having run out in December, the asteroid was followed further by graphic extrapolation. Vesta was followed from May, 1935, to February, 1936, by 142 observations; first found by our preliminary remarks, the object, after it had run off the chart, was recovered by extrapolation or continuation of path on the map. It was even seen by full-moon light. Similarly other asteroids were picked up, giving the following report: planet 1 Ceres, 93 observations; 2 Pallas, 68 observations; 3 Juno, 70 observations; 4 Vesta, 142; 6 Hebe, 13; 8 Flora, 10; 11 Parthenope, 36; 20 Massalia, 3; total, 435 separate observations.

Anteros is the name reported as given by the discoverer (Delporte of Uccle, Belgium) to the new asteroid 1936 CA. The name seems to be particularly well-chosen, for Anteros was supposed to be a god opposed to Eros, and our planet 433 Eros was at one time thought to come closest to us of any planetary object. Anteros is most interesting as approaching nearer the earth at times than any other such body. Computations show that about February 7 (before discovery) it was somewhat more than 1,200,000 miles away. An ephemeris was computed by Irving Meyer of Rutherford, New Jersey, from Maxwell and Wright's elements; this ephemeris and a diagram of a section of the orbits of the asteroid and the earth for pre-discovery positions show that Anteros moved over a considerable arc of the sky in a few days' time. This is explained by the crossing of the orbits in an "x" fashion, the earth and the asteroid being first on the right side, then on the left of the x, hence seen in almost exactly the opposite parts of the heavens on different dates.

An orbit diagram drawn by Hiller of the *Astronomisches Rechen-Institut* in Berlin-Dahlem shows the relations of the whole orbit to that of the other (major) planets. At perihelion, which took place in December, 1935, the asteroid is somewhat outside Mercury's orbit, and perihelion distance is less than one-half of an astronomical unit. The inclination to the ecliptic is only about 1°, and the period about 2 years. An ephemeris by Hiller indicates that on April 6 its brightness will reach only $19^{M}.0$, therefore placing this interesting object out of reach of all

but the greatest telescopes, and soon probably out of their reach, until, with its short period of revolution about the sun, it is recovered at future apparitions. The orbit reminds one very much of that of a comet, as the eccentricity is so large, being about 0.7 which is even greater than in the case of some of the comets. While commonly large eccentricity and big inclination to the ecliptic plane occur together, they do not do so in the case of 1936 CA. At the aphelion point the planetoid is about half-way between the orbits of Mars and Jupiter.

During April planet 1 Ceres starts from a point about 1° west of ξ Scorpii and moves westward about 3°; its magnitude in this interval averages $7^{M}.4$. Asteroid 2 Pallas is followed on our chart published in the preceding issue of this magazine, until April 22; it continues in a northwest direction until the middle of May, being 2½° southwest of the star 12 Boötis on May 2. Not many of the next-best one are easily available in small telescopes in April. 15 Eunomia, $9^{M}.6$, 132 Aethra, $9^{M}.5$, 405 Thia, $9^{M}.4$, and 44 Nysa, $9^{M}.7$ are all to be found in south declination, 132 in the first week of April being as far south as ε Centauri.

Hayden Planetarium, American Museum of Natural History,
New York City, March 22, 1936.

General Notes

Dr. Edwin P. Hubble, astronomer at the Mount Wilson Observatory, has been appointed to deliver the Rhodes Memorial Lectures at Oxford University for the year 1936-37. (*Nature,* February 22, 1936.)

Mr. Paul Herget, of Cincinnati, addressed the Eastbay Astronomical Association at its regular monthly meeting held at the Chabot Observatory, Oakland, California, on March 7, 1936. His subject was "Early History of the First Observatory in America." Mr. Herget at present is Morrison Fellow in Astronomy at the University of California.

Professor Armin O. Leuschner, Director of the Berkeley Astronomical Department of the University of California, has been awarded the Bruce Gold Medal for 1936 by the directors of the Astronomical Society of the Pacific. Dr. Seth B. Nicholson, of the Mount Wilson Observatory, in announcing the award summarized the various activities of Professor Leuschner which contributed to the decision of the directors.

The Rittenhouse Astronomical Society of Philadelphia held its monthly meeting on Friday evening, March 13, in the Hall of the Franklin Institute, 20th Street and the Parkway. This was Members' Night, and the program consisted of brief talks as follows: "More Paradoxes," by Richard P. Lochner; "Building an Amateur Observatory," by Harry B. Rumrill; "Photography at the Roslyn House Observatory," by Lewis P. Tabor.

Amateur Astronomers Association.—During the month of March the Amateur Astronomers Association of the American Museum of Natural History, New York City, held two regular meetings. The first, on March 4, was addressed by Mr. Joseph L. Richey, Chief Technical Operator of the Overseas Service of the American Telephone and Telegraph Company, on the subject "Astronomical Fac-

tors in Radio"; the second, on March 18, was addressed by Mr. Charles H. Coles of the Research Bureau of the Brooklyn Edison Company on the subject "Photographic Experiences in Astronomy." Motion pictures were used on both occasions.

Comet Medals Awarded.—The Donohoe Comet Medals of the Astronomical Society of the Pacific have been awarded to Wm. C. Jackson of the Union Observatory, Johannesburg, South Africa, for the discovery of an unexpected comet on June 19, 1935, and to Professor G. Van Biesbroeck of the Yerkes Observatory, Williams Bay, Wisconsin, for the discovery of an unexpected comet on August 21, 1935. The committee making the award consisted of Professors W. H. Wright, S. Einarsson, and H. M. Jeffers.

Shadow Bands.—The following interesting, though belated, account of an observation bearing upon the somewhat mysterious phenomenon of the "shadow bands" usually observed during a total eclipse of the sun, has recently reached us. Because of its novelty and apparent uniqueness, we are glad to publish it.

> During a partial eclipse of the sun in 1924 [presumably January 24, 1925], which occurred about eight-thirty in the morning, I noticed first against a white background the plainly visible shadows of the heat waves rising from my own body, even from the tip of my finger, and could then see the heat waves rise from my hand. I have tried since to detect such heat waves but have never been able to do so. It was only while the sun was in partial eclipse that the heat waves rising from the body were seen.
>
> This may be nothing new but, not finding any mention made of such an experience anywhere, I decided to write it to you since eclipses are not frequent and a minor thing of this kind might be overlooked.
>
> PHIL MCAFEE.

Johnson City, Tennessee, February 22, 1936.

Notes from the Yerkes Observatory.—Professor Bart J. Bok of Harvard College Observatory will give a course of lectures on "Stellar Statistics" at the Yerkes Observatory, beginning June 1. These lectures are intended for the members of the observatory staff, for graduate students, and for visiting astronomers. The course will be available for graduate credit in the Division of the Physical Sciences, provided that the graduate students start their work at the observatory on June 1, instead of at the official beginning of the summer quarter. All other courses will begin on June 22, 1936.

New appointments for 1936-1937 in the department of astronomy and astrophysics of the University of Chicago include the following: Dr. Bengt Strömgren of the University of Copenhagen as assistant professor of theoretical astrophysics; Dr. Philip C. Keenan of the Perkins Observatory as instructor in astrophysics at the Yerkes Observatory; Dr. Carl K. Seyfert of the Harvard College Observatory as astronomer at the McDonald Observatory; Mr. Paul Rudnick as astronomer at the McDonald Observatory; Mrs. Jessie Rudnick as assistant at the McDonald Observatory. Dr. S. Chandrasekhar is expected to join the staff of the Yerkes Observatory on January 1, 1937, as research associate in astrophysics.

In addition to the weekly colloquia by members of the observatory staff, the following lectures were given at the Yerkes Observatory during recent weeks:

Dr. S. Chandrasekhar, on "Stellar Structure" and "The Solar Chromosphere"; Dr. Oliver J. Lee, Director of the Dearborn Observatory, on "The Dearborn Survey of Faint Red Stars"; Dr. Arthur R. Sayer of the Dearborn Observatory on "A Spectrographic Study of Nova Ophiuchi 1933." During the months of April and May, Professor Walter Bartky of the University of Chicago will give a course of lectures at the observatory on "Classical Mechanics." This course, which will not be available for graduate credit, is intended as an introduction to modern work in wave-mechanics.

Yerkes Observatory, March 23, 1936.

The Harvard Summer School of Astronomy, inaugurated during the summer of 1935, will again be conducted from July 5 to August 16, 1936. Two formal courses, one entitled "Introduction to Cosmogony," and one, "The Planetary System" are announced. In addition there will be five seminars and opportunities for research under the direction of the members of the Harvard College Observatory staff. Among the visiting lecturers during the summer will be: Dr. Peter van de Kamp, University of Virginia; Dr. Alfred C. Lane, Tufts College; Dr. Knut Lundmark, University of Lund, Sweden; Dr. Paul W. Merrill, Mount Wilson Observatory; Dr. Henry N. Russell, Princeton University; Dr. Megh nad Saha, University of Allahabad, India; Dr. Frank Schlesinger, Yale University.

This will be an unusually interesting summer at Harvard because of the celebration of the Tercentenary of Harvard University. Special exhibits, lectures, and conferences will be held throughout the University during July, August, and September. Astronomers will have an added attraction in the meeting of the American Astronomical Society in Cambridge on September 2-5. At this meeting addresses will be given by Sir Arthur Eddington, Dr. Antonie Pannekoek, and Professor Henry Norris Russell, as contributions to the Tercentenary Conference.

Correction.—In my review of Aitken's new edition of "The Binary Stars," I attributed both the chapters of Radial Velocity and Orbits of Spectroscopic Binaries to Dr. J. H. Moore. Dr. Moore prepared only the first of these chapters, the second should be credited to Dr. Aitken.

PHILIP FOX.

Book Reviews

Through the Telescope, by Edward Arthur Fath. (The Whittlesey House, McGraw-Hill Book Co., New York City. $2.75.)

Dr. Edward Arthur Fath's new book "Through the Telescope" is a personally conducted tour through space. It is interestingly written in simple, non-technical language and beautifully and artistically illustrated with a hundred or more of the finest photographs obtained from America's leading observatories. If an interested reader were to do no more than thumb through the volume, reading the captions and legends accompanying the illustrations alone, he would gain a worthwhile concept of modern astronomy.

The author has dared to deviate from the accepted dignified rule of textbook making and introduced the vogue of the modern picture book advertising and placed beautiful cuts of the moon and Mars, the solar corona and asteroid trails flush with page edge or top margin. Excellent photographs of Venus, Jupiter,

and Saturn are strewn irregularly through the text. Reproductions of bizarre comets, meteor trails, and historic meteorites vie with each other to attract the reader's interest as he dreams along through what ordinarily would be dry and tedious reading, to find himself lost in the enthusiasm of the author.

The power and function of the telescope are revealed on every page of the text. The author's long experience at famous observatories serves him well in grasping the reading-interest point of view and knowing how to present his subject to a popular audience. His delineation of the solar system is so simple, accurate, and comprehensive that one cannot fail to form a true concept of his too little-known universe. His succinct, non-deceiving description of Mars gives the reader a realizable concept of this most talked of planet and prepares him for that disappointing experience when the opportunity to see it is given. That vexing, nongraspable group of objects known as asteroids is simply and, for the space given to the subject, adequately described.

Faithfully following the theme of his book the author keeps the reader conscious of the function of the telescope. His chapter on the Sun invites rereading because of the unique treatment of that subject which is invariably drawn into every conversation relative to our source of heat and light. His treatment of the discoveries of the three planets, Uranus, Neptune, and Pluto, combines history, romance, and science. He closes the first half of the book with the words, "We have now completed our swing around the solar system. We have studied the sun with its family of planets and the more erratic members of the family, the comets, meteors, meteorites, under highly favorable conditions." To all of which the reader heartily agrees.

Fath's astronomical tour now takes us from our homeland, the solar system, across abysmal depths to the stellar universe. Here, in true tourist fashion, he introduces us to some ancient history about stars and constellations, weaving primordial concept with modern discovery concerning these "points of light" which watched the earth grow fit for man. From facts about distances, sizes, temperatures, masses, and spectra of individual stars and a brief resumé of the various theories about variables, binaries, and new stars, our conductor leads us to a concept of our great galaxy popularly known as The Milky Way.

We now stop for a moment to catch our breath at the incomparable Mt. Wilson Observatory with its unrivaled instrumentality:—the 100-inch Hooker telescope; the 170-foot Tower telescope, and all the latest accessories known to modern science;—before plunging into the gaseous nebulae, obscure or dark nebulae, globular star clusters, and star clouds which make up the structure of our own spiral nebula. As if to add confusion worse confounded, we are permitted, through the 100-inch telescope, glimpses of extragalactic universes represented by the great spirals in the constellation of Andromeda, Triangulum, The Hunting Dogs; and as if Deity were anxious that we should understand the whole truth, one of these incomparable objects is seen edge on.

Lest one convolution of the brain should still remain unstretched, the concept of the expanding "multiverse" is presented in such comprehensible terms that any intelligent reader will not fail to grasp it.

The author suggests that his book can "Be read in one evening by a reasonably rapid reader." If any book surveying the whole field of astronomy can thus be vertically read, this book can; but such reading only serves to invite a rereading. "Through the Telescope" is admirably adapted for group reading, this is, reading aloud to an evening group gathered about the fireplace. It will be

found quite as interesting and, I dare say, inspiring as contract bridge or "bank night."

D. W. MOREHOUSE.

Drake University, Des Moines, Iowa.

Factor Table for Numbers less than 100,000. (British Association for the Advancement of Science Mathematical Tables, Vol. 5. Price 20/— net.)

This new table of all factors of numbers less than 100,000 will be welcomed by those whose work requires the use of such a table. The extreme care taken in the preparation of the original copies as well as in reading the proofs leads the committee in charge to believe that no errors exist. The type is large and clear and the pages sufficiently large to avoid crowding of figures.

The form of printing may be seen from the following example of the factors of 66660. The factors given are $2^2 \cdot 3 \cdot 5 \cdot 11 \cdot 101$. In the case of the prime number 66889 the number itself is printed.

In view of the fact that such a volume, while of the greatest value to some, can never become a "best seller" the price is remarkably low. This was made possible by the great amount of time donated by many individuals and by money grants from various sources.

E. A. F.

Junior Astronomy News is a publication which has already been mentioned in this magazine. It is published in mimeographed form by the Junior Astronomy Club at the Hayden Planetarium, New York City. The issue for March, 1936, has recently appeared. It contains a number of articles of interest to astronomically minded readers. Among the articles is one consisting of a collection of excerpts from poems having astronomy as their theme. Some of this possesses high poetical quality and some is merely amusing as it is intended to be. The publication shows enthusiasm and coöperation on the part of the members of the club which sponsors it.

New Numbers, by F. Emerson Andrews. (Harcourt, Brace and Company, 383 Madison Ave., New York City. $2.00).

A volume of 168 pages under the above title appeared late last year. It is an extension of two papers which appeared in the *Atlantic Monthly,* one in 1934 and one in 1935. In this volume the author brings out many interesting properties of numbers. He does not go deeply into the theory so that anyone with average powers of thought will be able to read it quite understandingly. Some very unexpected characteritics of numbers are exhibited. For example, he writes a number consisting of 102 digits so arranged that if the number be multiplied by 2, 3, 4, 5, and so on, up to 102 the cyclical sequence of the digits remains unchanged. Without giving the question careful consideration one might think such a combination of figures extremely difficult if not impossible to find. However, a little thought guided by the author reveals the absolute necessity of what seems so improbable.

Perhaps even more intriguing chapters are the ones in which the author develops in considerable detail the system of numbers using twelve as a base instead of ten as in the system now in use. He refers to it as the *dozemal* (from the word dozen) system instead of the decimal system. In this system one must become accustomed to such apparent inaccuracies as $4 \times 5 = 18$, and $7 \times 9 = 53$. The author insists, however, that, since the multiplication table must be a matter of memory in any case, for the beginner it might as well be in the new form as in the old one. The reason that the new combinations seem odd, even fantastic, is

that we are prejudiced by long experience and training in favor of the decimal system.

The author, indeed, shows many situations in which the *dozemal* system tends greatly to simplification as compared with the decimal sytem, notably in computations involving dozens. He does not seriously advocate adopting such a system of new numbers. The practically unsurmountable obstacles in the way of such a change are easily evident to everyone. Until the nations can agree to take the relatively simple step of adopting one of the simplified forms of the calendar which have been suggested, it would, indeed, be a futile undertaking to become a crusader for a new number system.

Nevertheless, all who are sufficiently familiar with numbers to feel the lure of them will find pleasure and even fascination in this work.

Jaunts into Space, by R. S. Underwood. (Christopher Publishing House, Boston, Massachusetts. $1.25.)

Glancing at the title and at the illustrations of this volume one does not know whether to take it seriously or to approach it with the idea of being amused. One does not need to read very far, however, if he has sufficient acquaintance with present day astronomy to afford a basis for judgment, before he realizes that the author has a clear understanding of the material he is dealing with, and that the book contains many facts interestingly presented. By the time the volume is finished the reader concludes that while he has not been amused he most certainly has been entertained and instructed.

The book is small and contains only seventy-nine pages, and consequently may be read in an hour or two. Of course, if one happens to meet some of the rather startling statements for the first time, he will wish to take some time to ponder them and to grasp their significance. The book abounds in comparisons and helpful illustrations. It also conains a number of fine photographs of celestial objects, and a few sketches, almost trivial but not without point. The author's style is easy flowing and sufficiently informal to hold one's attention closely. The reviewer eagerly testifies that he derived a couple of hours of keen enjoyment and pleasure from it. The writer noticed only one minor fault, and that can be overlooked, namely, that on page IX and again on page 29 the word "principle" is used when "principal" is meant.

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No. 500. The Analysis of Nova Emission Bands, by O. C. Wilson.
No. 501. Spectrophotometry of RS Ophiuchi (Nova Ophiuchi No. 3), by O. C. Wilson and E. G. Williams.
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